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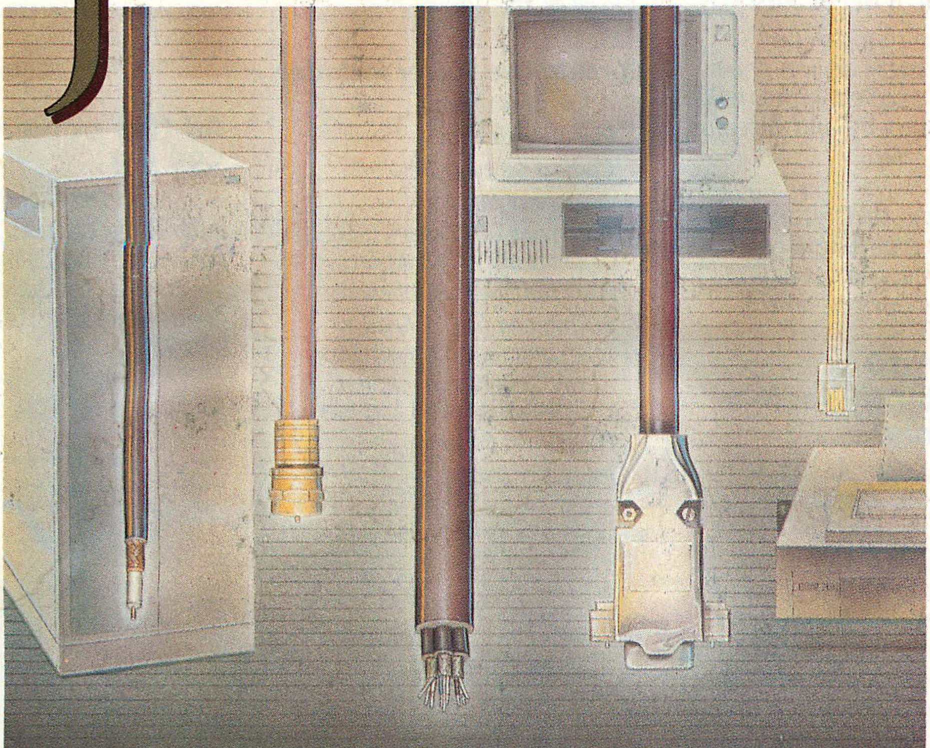

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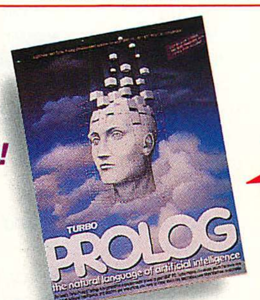

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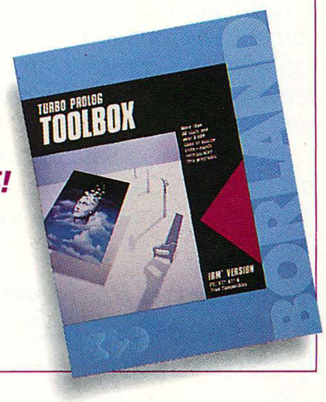

System requirements

Turbo Prolog: IBM PC, XT, AT or true compatibles. PC-DOS (MS-DOS) 2.0 or later. 384K. Turbo Prolog Toolbox requires Turbo Prolog 1.10 or higher. Dual-floppy disk drive or hard disk. 512K.

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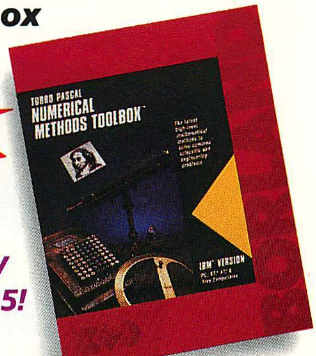

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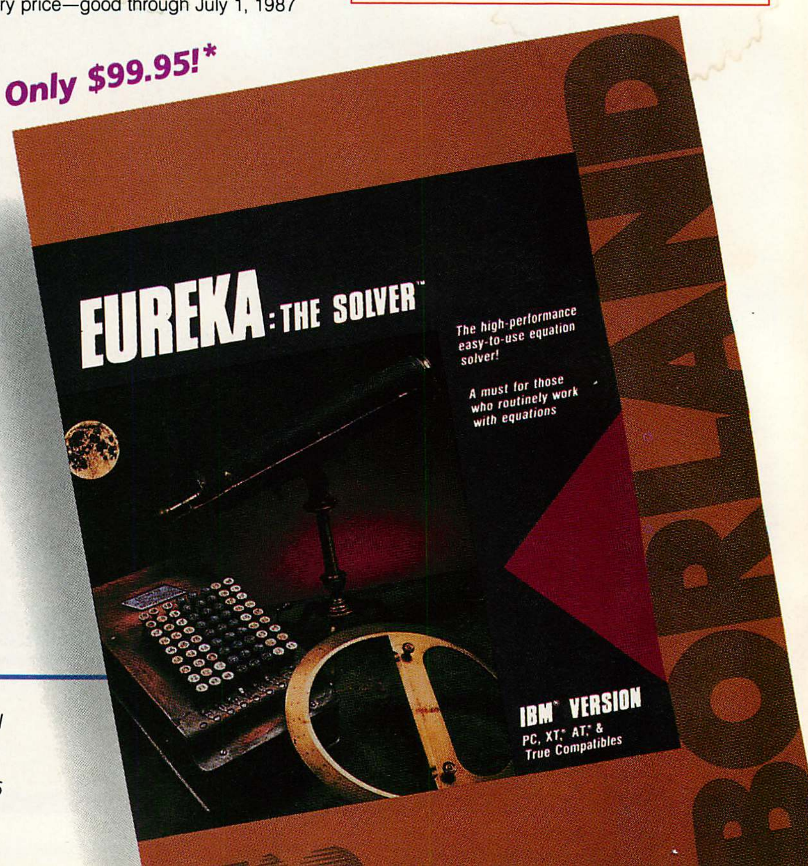

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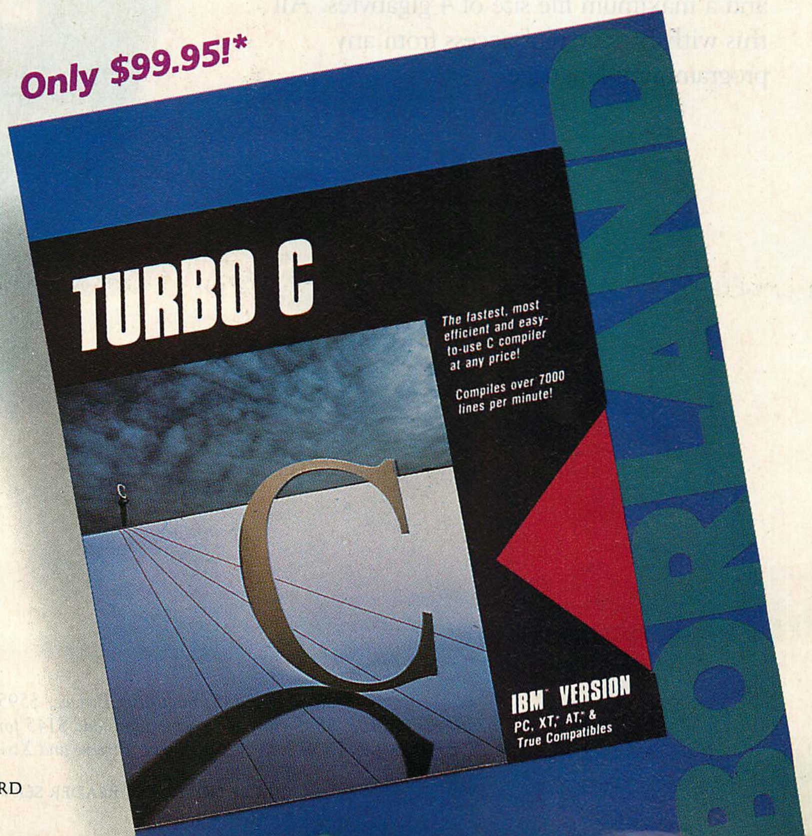

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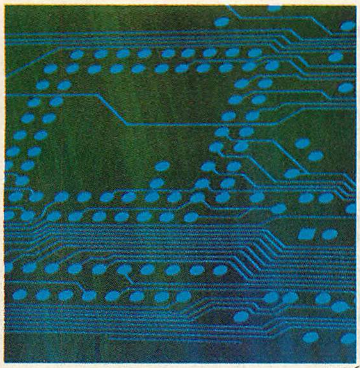

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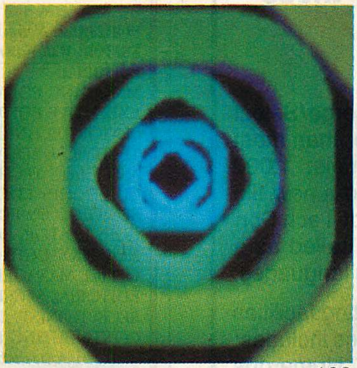

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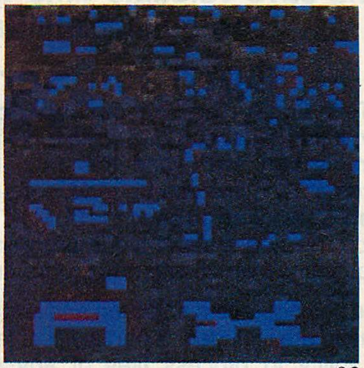

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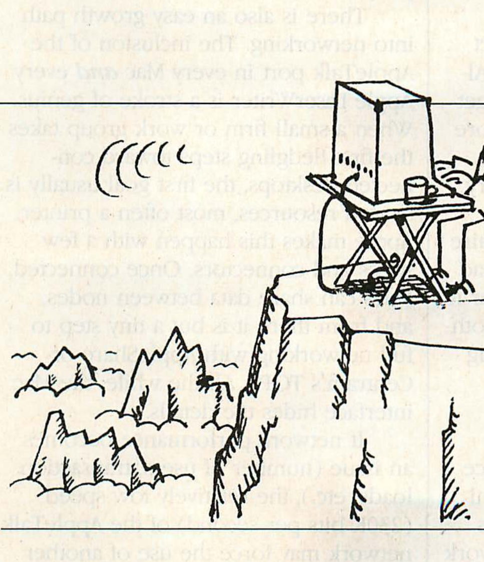


ILLUSTRATION • MACIEK ALBRECHT

Macintosh. It's a name that conjures up a most unbusiness-like image—one swirling in the mists of Apple folklore. It's almost laughable to the die-hard IBM installation. It's inconceivable to the power user whose AT is packed with fast hard disk, numeric coprocessor, and tons of RAM, and whose 386 machine is on order. Or is it?

Through 1986, the Macintosh Plus has been the weapon with which Apple has been making steady inroads into Corporate America. More and more companies are coming to understand the tremendous benefits of a single, standardized user interface; substantially reduced training costs are a real plum. The Mac's small footprint and relative transportability are attractive advantages. Microsoft's Excel spreadsheet has won rave reviews, and many believe it would surpass Lotus 1-2-3 in popularity were it available for the PC; Excel is selling Macs. With the AppleTalk network powering shared resources and providing basic connectivity, Apple has been able to offer simple, elegant, and cost-effective solutions for many users.

Now Apple has come forward with its new Macintosh products that significantly strengthen its marketing position and ability to penetrate business accounts. So, even though *PC Tech Journal* has always been oriented exclusively to the IBM standard, we feel compelled to comment.

MACINTOSH II

The big news, although somewhat anticlimactic after so many months of speculation, is the Macintosh II, fondly called the Open Mac. This is a product to be reckoned with.

The machine is a full 32-bit implementation of the Motorola 68020 processor operating at 16 MHz. The box includes six open-architecture expansion slots, one of which is required for the Mac II video card. This new display adapter drives either a monochrome or color display with a resolution of 640-by-480 pixels; it can simultaneously display 16 colors (an option increases that to 256) selected from a palette of 16 million. The Motorola 68881 floating-point chip is standard, and the Motorola 68851 memory management chip is optional. The Mac II has the Small Computer Systems Interface (SCSI), RS-422, Apple Desktop Bus (ADB), and AppleTalk ports built in, as well as a four-channel, stereo sound facility.

The Mac II's bus uses the industry-standard NuBus architecture, a full 32-bit implementation that matches most features of IBM's new Micro Channel bus, such as arbitration and better signal versus noise detection. I said in last month's column that with the Personal System/2 IBM brought minicomputer technology to the desktop; actually, Apple beat IBM by a month.

The list price for the Mac II with 1MB of memory, a 40MB internal hard disk, and the Apple extended keyboard is $5,598; with color monitor ($999) and video card ($499), the total is about $7,100. At first glance that might seem like a lot of money to invest in a desktop machine. An inevitable comparison reveals a similarly equipped Compaq Deskpro 386 (using Compaq's enhanced graphics display) for $7,900. An IBM Personal System/2 Model 80 lists for $7,600. Assuming that the Mac II is in the same class as these 386-based machines, it holds a significant price advantage. Keep in mind that the price of the IBM-standard machines does not include the mouse or ports for the network, SCSI, and ADB.

Whether the Mac II is really in the same class as a 386 machine probably has less to do with raw performance and features, and more to do with style and approach. The machine looks for all the world like a PC, with its enhanced keyboard and its separate system unit and display. It also looks like a workstation, with its higher graphics resolution, UNIX implementation, and new Ethernet card. And it still looks like a Macintosh, with perhaps 95 percent (Apple's number; others say 80 percent) of Mac code running unmodified. It is clearly several machines rolled into one, with nothing sacrificed.

CAN APPLE DO IT?

Even given Apple's rising star (second quarter net sales were up 41 percent, the stock split, and Apple issued its first dividend), the Macintosh undoubtedly will still be a tough sell. Part of this is due to the image of Apple created by Steve Jobs' zealotry and near fanatical obsession with the Mac interface and closed systems. Some of his vision was

right, of course, but button-down Corporate America had problems with his evangelical sales pitch for a machine with no slots and no software.

Today that image is changing, but the potential buyer still may have to "get religion" to fully accept Apple. Business people usually prefer business-like dealings with their vendors. Trust in a computer company and its dealers is very important to a company that is planning to make large purchases, especially when Apple's direct sales force is shrinking (by choice). Although there still may be problems getting the retail channel to become more business-oriented, I can report from personal experience that Apple is very serious, and very business-like.

The Mac interface also may require the buyer to get religion. You can read about it over and over again and hear it from dozens of satisfied users, but nothing makes it sink in like actually using it. Microsoft Windows is just not the same, although it is moving closer. Apple is ahead of IBM here. Apple's early commitment to the Mac interface as a *standard* gave the company a unified operating environment across its systems that makes all applications work alike. It is valuable common ground missing from the IBM standard.

If the buyer can get past these two emotional hurdles, other concerns begin to fall away. Yes, plenty of software is available—some of it improved over similar products for the PC because it exploits the Mac environment to full advantage. Yes, a full complement of hardware and software provides IBM connectivity, particularly in the 3270 area. Yes, transportability of data from the Mac to the PC and back is possible, with many solutions from many vendors. And yes, a new wave of third-party add-in boards has rolled in with 86-family processors that run MS-DOS and PC applications software (although these are likely to be as popular as add-in CP/M boards for the PC were as soon as people start using the Mac interface).

There is also an easy growth path into networking. The inclusion of the AppleTalk port in every Mac *and* every Apple LaserWriter is a stroke of genius. When a small firm or work group takes the first fledgling steps toward connected desktops, the first goal usually is shared resources, most often a printer. Apple makes this happen with a few wires and connectors. Once connected, Macs can share data between nodes, and from there it is but a tiny step to full networking with AppleShare or Centram's TOPS. All the while, the Mac interface hides the details.

If network performance becomes an issue (number of users, transaction loads, etc.), the relatively low speed (230K bits per second) of the AppleTalk network may force the use of another network, perhaps Ethernet. Such cases afford many alternatives, such as using small AppleTalk clusters attached to an Ethernet backbone. Nonetheless, most of the details remain transparent.

Apple's approach to networking is in sharp contrast to IBM's, whose PCs have no built-in ports, no built-in software, no printers that can live by themselves on a network (there are a few Ethernet exceptions), and no growth path. The IBM world seems to require either an immediate jump into full-scale, expensive networking or a low-end solution with no growth potential, one that probably must be tossed when the full-scale solution is required. Apple really leverages the work group at the outset and clearly has the advantage.

THE RISE OF THE CASUAL USER

If nothing else, the Mac is really appreciated by what Rick Richardson, of Arthur Young in New York, calls the *casual user*. He contrasts such users with the *power user* (a term he claims to have coined) by pointing out that the casual user is interested in the result (what work the computer helped accomplish), while the power user is more interested in the process (how the computer did it). Richardson says that his studies show the casual user is in the majority: about 80 percent of workers who could benefit from a desktop computer are casual users.

Corporate America is beginning to realize that Mac does a better job addressing the needs of the casual user than the typical PC, and both Apple and IBM know that this sizable market must be won. Apple fired a first salvo with the new machines (including one for the power user) and is expected to follow quickly (the rumors say June) with extensions to the Mac interface that allow multitasking. IBM has offered new, more integrated machines and has promised the new operating system with Presentation Manager, its built-in graphical user interface.

Both Apple and IBM have high hopes for their new systems in Corporate America. Apple expects to breach the IBM fortifications with machines it considers far superior to the IBM standard. IBM expects to reestablish its dominance in a market it has watched rapidly erode. Apple is attacking; IBM is finally emerging from its long-standing defensive position.

With the new Mac lineup, Apple has a strong story to tell.

VOTE!

From time to time, *PC Tech Journal* will include a ballot card like the one bound in on the previous page. We will use the card to get your quick opinion on various topics. It is not scientific, but as long as the results are not too close they should represent your position.

Our first question is about the new Macintosh II. You heard my opinion; now let your voice be heard.

CROSSING THE GREAT DIVIDE

It goes without saying that the *PC Tech Journal* audience has a heavy investment in IBM and compatible desktop equipment. That makes considering the Macintosh risky unless some way exists to enable movement of data back and forth freely between the two worlds of IBM and Apple.

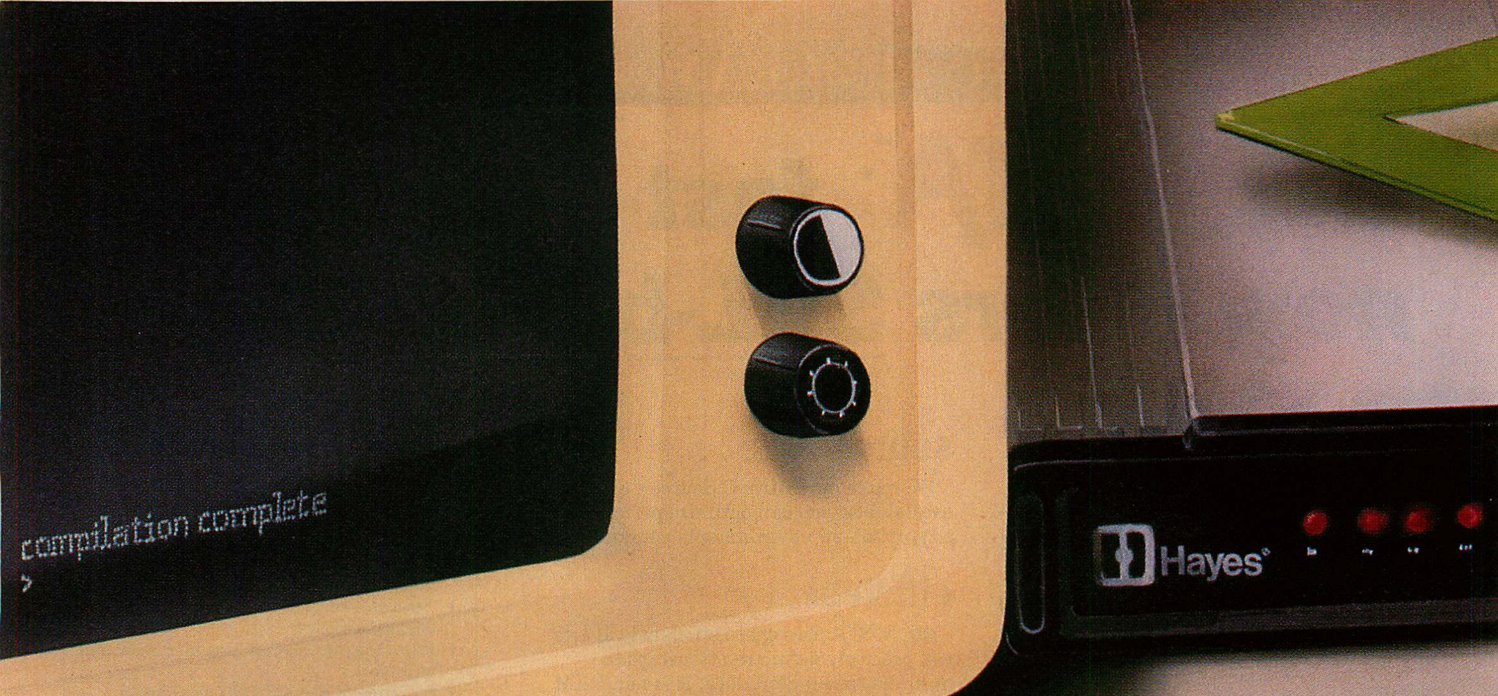
Apple offers a 5¼-inch diskette drive and a file transfer program called InterFile that allows MS-DOS disks to be read. Third-party vendors provide add-in hardware to allow the execution of DOS and its applications in a Mac window; this is the "have your cake and eat it, too" solution.

Networking solutions also are possible. Centram's TOPS, a network environment, allows Macs and PCs to share data transparently. Apple's AppleShare has similar capabilities. Both companies supply adapters for use with the IBM compatibles.

One of the most effective data interchange devices may prove to be Microsoft Excel. This spreadsheet does not have the typical data import/export facility. Instead, the user loads the desired file; thereafter, Excel saves it in the desired format. So, for example, Excel and 1-2-3 users can share the same data file, kept in 1-2-3 .WKS format, across the network.

These solutions are not a total answer. However, expect to see an increasing number of applications that either run in both environments or include specific features to deal with a multiuser, multivendor environment.

—WF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Jerry Pournelle, columnist for BYTE magazine summed it all up by saying BRIEF is, "**Recommended. If you need a general purpose PC programming editor, look no further.**" His point of view has been affirmed by rave reviews in C JOURNAL, COMPUTER LANGUAGE, DR. DOBB'S JOURNAL, DATA BASED ADVISOR, INFOWORLD AND PC MAGAZINE.

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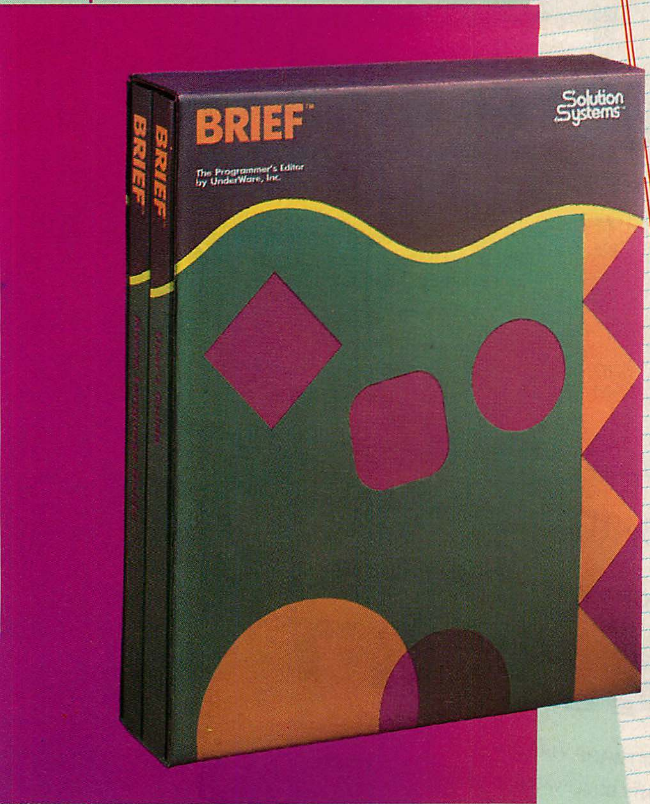

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Main Features:

- *All new documentation with tutorials on basic editing, regular expressions* **and** *the BRIEF Macro Language.*
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- *More block types, with marking by character, line or column.*
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Plus the basic features that made BRIEF **SO** popular!

Basic Features:

- *Full multi-level Undo*
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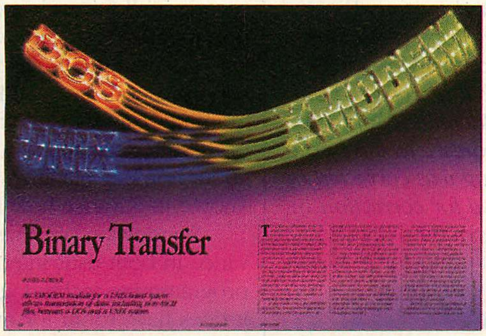
- *Automatic language sensitive indentation*

Requires an IBM PC or compatible with at least 192K RAM.



MAKING THE RIGHT CALL

Regarding "Binary Transfer" by Ronald Florence (March 1987, p. 144), the packet-reading loops shown will perform poorly on most UNIX systems. Good-looking code like Mr. Florence's shouldn't be nitpicked, but I have seen serial communications software similar to his program, XMODEM, degrade the performance of large VAXes.

The code shown will invoke three system calls per incoming character. The problem is minimized by acquiring the packets with a single read of the right number of characters.

Also note that the tactic of using **alarm( )** calls to provoke a time-out will fail on some systems (that is, 4.2 BSD on Sun computers) because in the case of **ttys** the **read( )** call will reenter as if nothing had happened. **Setjmp( )** and **longjmp( )** can be used in these cases.

Eliot W. Dudley
New Methods Research, Inc.
Syracuse, NY

*Mr. Dudley is correct—reading incoming packets with a single **read()** call would be more efficient than using a loop to read a character at a time. However, with many UNIX systems a **read()** on a communications line may return fewer than the number of bytes requested. Reading a character at a time does place a greater overhead on the system, especially at 4800 or 9600 baud, but the code is easy to implement.*

*Using **longjmp()** and **setjmp()** might also be more portable than using the **alarm()** calls to trigger time-outs. I chose the latter option to make the program simple for non-UNIX users.*

—Ronald Florence

TO BE MORE PRECISE

As an early user of ASYSTANT+ and its parent language ASYST, I commend the thorough treatment of the product in the February 1987 review ("Desktop Data Acquisition," Victor E. Wright, p. 106). However, the reviewer should have done a little more serious number crunching. ASYST has a flaw that has persisted since its introduction, despite numerous complaints to Macmillan and Adaptable Laboratory Software (ALS).

In release 1.5, the language included a feature that, if a numerical result were less than the value representable in single precision, would stop the program with an error message. (If in double precision, the same was true at a lower magnitude.) This will occur in many scientific problems, especially in arrays of numbers representing whole functions. This made the language useless for serious computing, yet ALS remained adamant in not changing it.

Finally, when parts of ASYSTANT+ simply would not run, ASYST was "fixed." Release 1.53 included a README file saying that such numbers would be set to zero, which, of course, they should be. However, the fix was flawed. A range of numbers exists near the lower end of both single- and double-precision numbers in which the program stops with the uninformative message, "Error 155-Invalid 8087 operation." Anyone can reproduce this message by typing **1E-39 1 ***. This will be encountered in any serious numerical problem sooner or later. I have had a problem stop after 25 minutes of computing, invalidating all results.

The company's hot line offers no advice on how to prevent the problem. At first it was suggested that inputs to computations be "controlled" to avoid that range. Macmillan has no plan to issue a general fix before the next release (2.0)—this for a problem that has existed since the first release! The plan is to mail fix-up disks to those who call and ask. The annual fee for support is $275, which would seem more than sufficient to cover the costs of sending the disks to frustrated users.

Russ Roberts, Ph.D.
La Habra, CA

*Although I did not perform the number-crunching test that would have revealed the flaw described by Dr. Roberts, I maintain that ASYSTANT+ is a powerful and worthwhile program. The fact remains, however, that it is afflicted with a bug. As Dr. Roberts points out, the expression "1E-39 1 *" stops ASYSTANT+ cold, with a cryptic message that says, "Error 155-Invalid 8087 operation. Press any key to continue..." So do similar expressions ranging from "1E-38 1 *" to "1E-45 1 *". On the other hand, expressions ranging from "1E-46 1 *" to "1E-308 1 *" do not produce such an error message.*

To make matters worse, pressing any key to continue places not one but two values on the stack. The first value is .0000 (REAL), the second is 1546 (DP.INTEGER). Following Dr. Roberts' reasoning, the pause might be acceptable if an acceptable result (0) were produced, and calculations could continue without invalidating the results obtained to that point.

The problem, according to Macmillan, is an underflow condition. Early versions of ASYST merely notified the user of this condition, as the original programmers felt most users would not want to continue with calculations. An attempt to provide the option to continue with calculations resulted in the current situation. Error 155 is not the only error that may be encountered.

A work-around is available. If the error condition is encountered in single-precision, the calculations can be repeated in double-precision mode. Then, calculations can proceed with values past the order of 1E-300. Although I can imagine Dr. Roberts' frustration of losing a 25-minute calculation—having on several occasions lost book chapters and major portions of articles to the whims of various word processors—I am confident that using ASYSTANT+ is far superior to doing those same calculations with the old Marchant calculator

(and certainly to submitting a card deck to the computer department).

I do endorse Dr. Roberts' position that we should expect software publishers to correct bugs that are pointed out so clearly. In fact, Macmillan Software does seem to be responsive to this particular problem. The bug was corrected in ASYST *and is scheduled for correction in a future release of* ASYSTANT+.

—Victor E. Wright

DRAFTY WINDOWS

I read Will Fastie's editorial comments on Microsoft Windows with interest (see "Far Afield with Windows," Directions, February 1987, p. 9), having just finished work on a fairly involved Windows application. Although I do not wish to defend the proposition that Windows is perfect, I do believe that the tone of the editorial was excessively negative for several reasons.

First, Windows is in release 1.03. Does anyone remember DOS 1.0 or 1.1? There is little question that the success of the PC-DOS/MS-DOS architecture was significantly promoted by the advent of DOS 2.0, not least of all because of the superior interface given to the software developer. This is not to make excuses for the current version of Windows, but rather to point out that most software improves in revision.

Comments that Macintosh provides a superior environment for development are also forgetful of the early days of the Mac. A fairly long interval followed the release of the Mac, during which the only software available for the machine was the original group (MacWrite, MacPaint, and so on).

There is no question that programming for Windows involves the assimilation of a novel and somewhat cryptic methodology, a challenge even for those thoroughly versed in both the C language and the PC environment. However, when one considers the complexity of the situation—multiple programs, all active simultaneously and sharing the same screen—this methodology is only to be expected.

Rather than complain about the unfamiliarity of it all, I would congratulate Microsoft for having made all of the new facilities available in a logical and consistent (if somewhat tedious) way. Once the initial learning process is over, the peculiarities of the Windows environment disappear, and one is back to programming as usual.

I would go further to say that the fact that the mechanics of the user interface are inherent in the environment relieves the programmer of the need to recode it all for each program, an important factor at a time when the market is demanding both consistency and sophistication. Under Windows, the programmer can concentrate on the logic of the interface and not worry so much about implementation, since it can be known in advance how it will work.

Windows represents a major advance in both user interface and PC programming technology. The fact that it does have room for improvement, and that it has not been received with universal enthusiasm, should not obscure this underlying reality.

Donald J. Pajerek
Penfield, NY

I tried to reflect upon what I had been told by developers, and I heard a very consistent story. Nevertheless, I do not disagree with the points in Mr. Pajerek's letter. It is just that no matter what Microsoft has really been doing, its people have been giving the appearance of doing little either to advance the product or to appease developers.

We know that is not really the case, and in light of IBM's recent announcements, we know why. Still, many developers who are committing their resources to advancing a Microsoft standard feel mistreated by the company, which now must mend some fences.

—WF

We recently bought an IBM PC/AT for our office. It is equipped with an 80287 numeric coprocessor, a Hercules Graphics Card, a monochrome display, a PC NT thermoprinter II, and a Microsoft Mouse. It runs under DOS 3.2. We wanted to run MS Write under Windows, and it worked fine until we attempted to print. Unfortunately, Windows does not include a printer file for our printer. We tried the various printer files provided with Windows. For the most part, they produced incomprehensible print text, except the file for the HP LaserJet printer. That one printed our text, but the left half of the paper was crowded with command markers. We have asked an outside company to write the necessary software for us, but the software would be as expensive as the printer itself. Is there a more reasonable solution to our problem?

Dr. Edgar Haegele
Spatzenhausen, West Germany

Regrettably, no. Microsoft's official position is that hardware vendors must provide Windows drivers for their products.

Continued on p. 21

By any measure, Microsoft® QuickBASIC 2.0 was an outstanding success.

We'd taken all the things people loved in the BASICA interpreter, and added a ton of advanced features to make a compiler that was faster and more advanced than any BASIC ever.

A compiler that overwhelmed even the toughest judges:

“A snazzy new programming tool that bridges the gap between earlier BASICs and the high-performance languages like C.” Peter H. Lewis, *The New York Times,* July 15, 1986.

“(Microsoft QuickBASIC) ...represents an outstanding contribution to the microcomputer world.” Dennis Dykstra, *Byte,* February 1987.*

PC Magazine was so impressed, in fact, that they gave Microsoft QuickBASIC their Technical Excellence award. Before long, Microsoft QuickBASIC 2.0 was the most award-winning BASIC compiler ever.

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This debugger is completely integrated into the compiler. So you can, for example, start debugging your program while it's running by simply pressing CTRL-Break. Instantly, the debugger is activated and you're in control again.

Faster math. And faster programming.

On PCs equipped with math coprocessors, Microsoft QuickBASIC 3.0 blazes through calculations. Our new in-line 8087 code is as fast as you can get. And that's just the start of the speed advantages.

“Microsoft QuickBASIC is phenomenally fast in compilation...(it) outstrips all other compilers.” Marty Franz, *PC Tech Journal,* December 1986.

Fast compiling is nice, but it's not the most important consideration. Program development time is.

Microsoft QuickBASIC makes your programming substantially faster by integrating a sophisticated editor into the compiler itself.

Any errors found during compilation trigger the editor to take over, putting your cursor right on the trouble spot.

And if you have more than one error, the editor will keep track of them all, letting you fix your bugs one after another. No more hassles with the endless recompiling of other compilers.

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Microsoft QuickBASIC gives you the power of advanced languages without the headaches. A case in point: separate compilation.

Long used in languages like C, separate compilation simply means that you can compile your programs the same way you write them, a piece at a time. Once compiled, your individual modules can be combined into libraries and added to future programs without the bother of recompiling.

But that's just one way Microsoft QuickBASIC supports structured programming.

In addition to the previous Microsoft QuickBASIC extensions like block IF/THEN/ELSE statements, Version 3.0 adds a new set of control structures. Features like the new SELECT CASE, DO WHILE, and DO UNTIL make even the most complex programs amenable to reason.

Still the same. Only better.

After all this work on improvements, we didn't forget what made Microsoft QuickBASIC the success it is. This compiler is still the leader in BASICA compatibility. From graphics to sound, this BASIC commands the PC like no other.

For more Microsoft QuickBASIC advantages, just turn the page.

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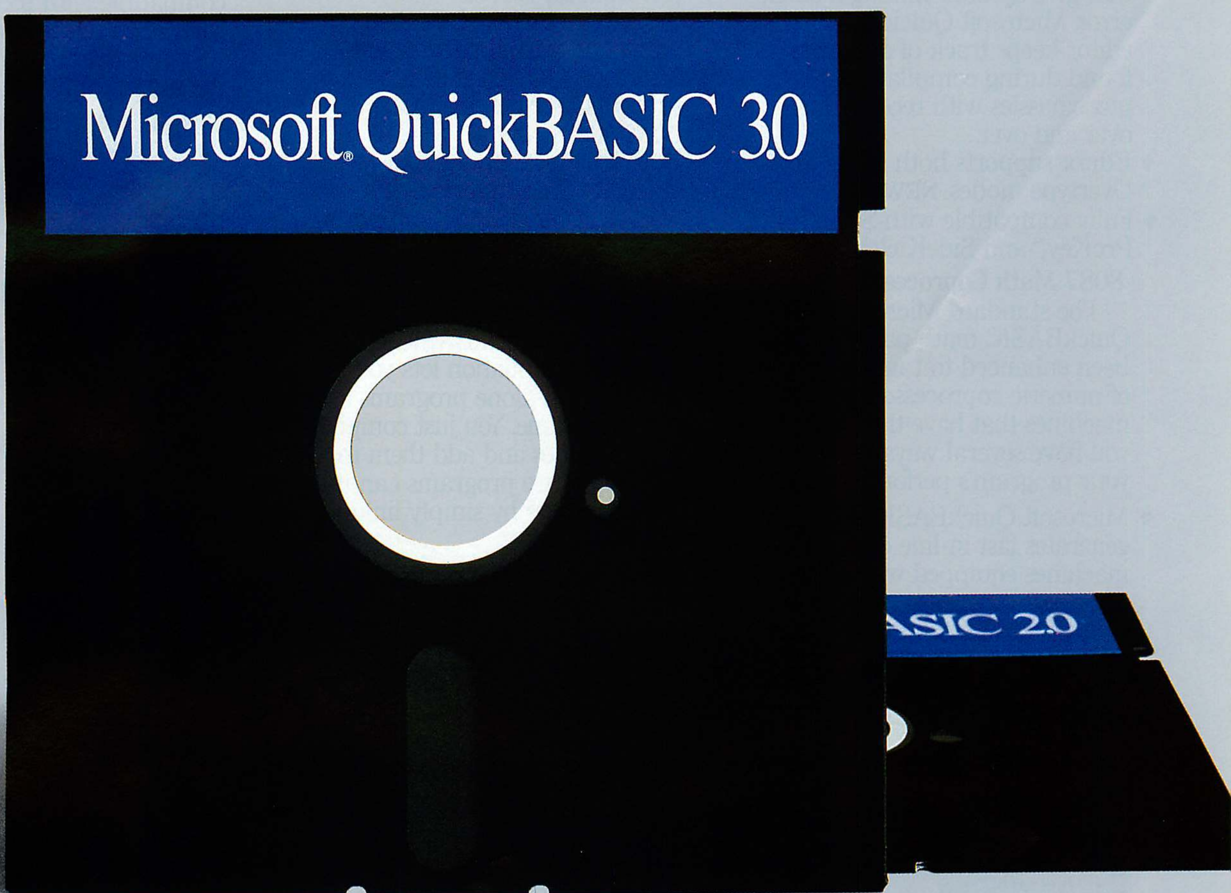
Introducing Microsoft QuickBASIC 3.0.



Integrated Program Debugging.

Microsoft QuickBASIC 3.0 includes the most advanced BASIC debugger available. This built-in debugger lets you track both program flow and the contents of variables with ease.

- ♦ Three debugging modes: single-step, trace, and animate.
- ♦ Set, clear, and examine breakpoints. NEW!
- ♦ Adjustable windows let you view source code, variable contents, and program output—all at the same time. NEW!
- ♦ Display and search through source code while debugging. NEW!

Advanced Integrated Editor.

The Microsoft QuickBASIC Editor is integrated with the compiler to make all your programming as fast and efficient as possible.

- ♦ Built-in editor places cursor on problem in source when error occurs in compilation.
- ♦ In contrast to other compilers that give up after finding a single error, Microsoft QuickBASIC's editor keeps track of all errors found during compilation. No more hassles with recompiling over and over.
- ♦ Editor supports both Insert and Overtype modes. NEW!
- ♦ Fully compatible with SuperKey,® ProKey,™ and SideKick.® NEW!

8087 Math Coprocessor Support.

The standard Microsoft QuickBASIC math package has been enhanced to take advantage of numeric coprocessors in machines that have them. Now you have several ways to optimize your program's performance.

- ♦ Microsoft QuickBASIC 3.0 generates fast in-line code for machines equipped with 8087 or 80287 coprocessors. Now your programs can be as fast as the hardware allows. NEW!
- ♦ Microsoft QuickBASIC includes full 80-bit IEEE Math support for programs that demand the most precise calculations possible. NEW!
- ♦ Choose from the Microsoft Binary Math routines for faster math or the new 8087 software emulation routines for more accuracy when you don't have a coprocessor.

Structured Programming Support.

In addition to the standard BASICA commands, Microsoft QuickBASIC Version 3.0 has a variety of advanced statements and features similar to those found in C and Pascal. By making structured programming easy, Microsoft QuickBASIC makes programs both easier to write and easier to maintain. Older BASIC features like line numbers and GOTO statements are strictly optional.

- ♦ New statements include SELECT CASE, DO WHILE and DO UNTIL, LOOP WHILE and LOOP UNTIL, and EXIT. NEW!
- ♦ Block IF/THEN/ELSE/END IF statements virtually eliminate any need for GOTOs.
- ♦ Subprograms may be called by name and passed parameters.
- ♦ Microsoft QuickBASIC now supports user-defined CONSTANTS. NEW!
- ♦ Both true local and global variables are supported.
- ♦ Microsoft QuickBASIC supports alphanumeric labels as well as line numbers.

Modular Programming Support.

Microsoft QuickBASIC's separate compilation lets you create stand-alone programs a piece at a time. You just compile your routines and add them to a library. Future programs can use those routines by simply linking in your libraries.

- ♦ Create stand-alone programs, with or without a separate run-time package.
- ♦ Link support routines once at beginning of a programming session, then forget about linking.
- ♦ Includes library for access to DOS and BIOS interrupts.
- ♦ Microsoft QuickBASIC makes it easy to use professional support libraries such as Softcraft's Btrieve package.

A compiler with both speed and power.

Microsoft QuickBASIC gives you the most advanced compiler features and debugging possible, without any speed handicaps. Microsoft QuickBASIC 3.0 compiles code up to an astonishing 12,000 lines per minute on an IBM® PC/AT.

Microsoft QuickBASIC also supports extra-large programs. Your programs can use all available memory for any mix of code and data. Individual arrays may use up to 64K bytes each (to the PC's limit of 640K).

BASICA Compatibility.

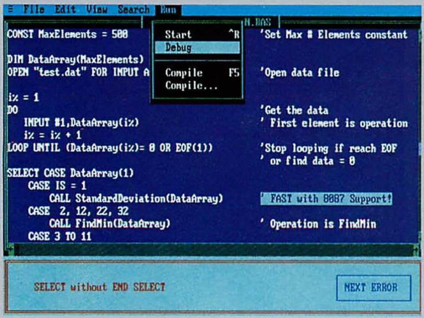
It's not hard to see why Microsoft's QuickBASIC is more compatible with IBM's BASICA than any other compiler. After all, we wrote it for IBM. And we've kept the same features in Version 3.0.

- ♦ Graphics statements include WINDOW, VIEW, DRAW, GET, PUT, LINE, CIRCLE, LOCATE, and SCREEN.
- ♦ Sound statements include SOUND and PLAY.
- ♦ Support for EGA extended graphics modes including the new 43 line mode.
- ♦ Supports standard BASICA structures such as GOSUB/RETURN, WHILE/WEND, and event handling.

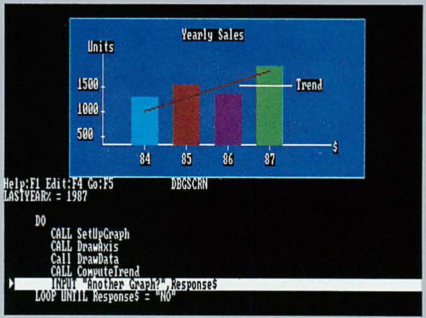
Dramatic execution speed enhancements.

Benchmark	Microsoft QuickBASIC 2.0	Microsoft QuickBASIC 3.0
Graphics (500 Circles)	21.42	9.83
Floating Point Math	16.92	6.48
Quick Sort	5.27	3.02

All test results in seconds. Tests were performed on an IBM PC/AT equipped with an 80287 coprocessor and an 8 MHz clock.



Programming is easier with the built-in editor that searches for all errors, letting you correct them and recompile without leaving the programming environment.



Pinpoint errors by tracing through your source code with the integrated debugger. You can set breakpoints and observe the contents of variables.

Microsoft® QuickBASIC

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PC MAGAZINE EDITOR'S CHOICE

*...one package stands out as the best support available for Turbo Pascal programmers: **Blaise Computing's Turbo Power Tools.** This definitive set of prewritten Pascal functions and procedures will make the life of any programmer—from the beginner to the hard-core professional—easier and more productive.*

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CIRCLE NO. 104 ON READER SERVICE CARD

Initially, Microsoft took the burden of development by providing support for the most commonly used devices, but it does not intend to keep doing so.

Until the manufacturer of your printer provides the driver, your only option is to use a word processor that knows about your printer.

—*WF*

dBASE WINGS CLIPPED

The article "Dialects of dBASE" by Ted Mirecki (April 1987, p. 46) is inaccurate and misleading. Mr. Mirecki states in his conclusion that Clipper programs are the slowest of all the products tested, including dBASE III PLUS, especially in disk-intensive activities. I would suggest that Mr. Mirecki try using an application that is more consistent with the real world in his next product review.

Granted, dBASE III PLUS will sort, copy one file to another, and remove deleted records (pack) more quickly than a Clipper program, but this needs to be qualified. dBASE III PLUS will perform these tasks more quickly if that is the extent of the program (that is, a single program consisting of several lines that copies one file to another, or sorts a file, or removes deleted records). Seldom is this all that is required of a program or an application.

I am a senior programmer for a consulting firm. I have been using dBASE II, III, and III PLUS for four years, and I have used Clipper nearly from its introduction. I have written applications ranging from general ledger accounting to medical billing and client tracking, the latter being very disk-intensive. I started using Clipper to try to increase the speed of the applications. The results are exactly what I expected from a compiler: the speeds have increased an average 2 to 20 times over those I experienced using dBASE III PLUS.

How do I manage this speed increase with a compiler that, from all appearances, performs certain disk-intensive tasks more slowly than dBASE III? The answers are simple though they often are overlooked, as they were in the article by Mr. Mirecki.

First, an interpreter such as dBASE will load a program from the disk, then interpret each line. If the program runs another program, the interpreter must load it from the disk, and begin interpreting the lines of code. A compiled application will hold the executable code for many programs in memory at one time, eliminating the time-consuming process of loading a program from disk each time it is called.

Second, the execution speed of dBASE III PLUS decreases dramatically as more and more programs are called and it has to keep track of more and more information (file pointers and so on). More time and memory are allocated to "housekeeping," thus slowing the interpretation of source code into executable code and execution. A compiler can devote its time to performing housekeeping and execution tasks since the lines of code are already interpreted and ready to execute.

I have yet to write an application for which the execution speed did not improve with compilation, contrary to Mr. Mirecki's conclusions. dBASE III PLUS is painfully slow when compared with a Clipper-compiled application. In every other article I have read comparing dBASE and compilers, dBASE has finished last in the speed department.

Finally, I wrote a test program to add 900 records to an empty database to test Mr. Mirecki's results. The program, when run with dBASE III PLUS, took 2 minutes, 58 seconds. The same program, compiled using Clipper, ran in 9 seconds—almost 20 times faster. The test was performed on an AT&T 6300 running at 6 MHz with 640KB, DOS 2.11, and an ST 225 20MB hard-disk drive. Mr. Mirecki performs a similar test, but his results show Clipper taking better than 3 times as long. Clipper, beyond a doubt, will add records to a data file much more rapidly than dBASE III PLUS. Is his result a misprint?

Bruce Trimpop
Echo Consulting Services, Inc.
Conway, N.H.

I would like to thank *PC Tech Journal* for devoting so much attention to the dBASE world. Based on surveys I have seen, dBASE users are a significant portion of your readership. Although this attention is a long time in coming, it is, as they say, better late than never.

It is unfortunate, however, that in attempts to make amends for ignoring this important marketplace, you chose to take on the impossible task of reviewing three products at the same time. In doing so, we feel, quite frankly, that Mr. Mirecki missed the boat.

Clipper is much more than a simple add-on product to dBASE. Nantucket was a pioneer in legitimizing the dBASE language for professional developers. Clipper was the first product to increase the performance of dBASE while, at the same time, expanding its language capabilities. It was never meant to be a faster dBASE interpreter. Our goal was to remove the barriers restricting dBASE programmers and provide them with the capabilities to produce the finest application program possible. Clipper is, in fact, a language in its own right with more than 40,000 users worldwide. We feel that this review did not even scratch the surface of Clipper's capabilities. To attempt to review it in such a superficial fashion is insulting, both to Nantucket and to your readership, most of whom are professional developers and deserve better information.

Your review does not stop at insult, however, but continues on to the level of injury by implying that Nantucket misrepresents the performance of Clipper. In response, we can only say that we stand by our claims.

I am not even sure how Mr. Mirecki reached his conclusions, since the benchmarks showed Clipper to surpass dBASE in 7 of the 10 tests. Regardless, the benchmarks do not accurately represent what programs actually do in real life situations. Our developers con-

centrate their efforts on those areas of program performance that enhance activities frequently performed in day-to-day operations rather than those areas that look good in simplistic benchmarks. In this type of situation, we look impressive against all competitors.

For those readers who may have some doubts about Clipper, we ask only that they speak to a Clipper user. We at Nantucket are confident that they will attest to the quality of our product. Tens of thousands of application programs have been written and compiled in Clipper in every segment of the marketplace. Clipper continues to be the choice of professional developers interested in producing state-of-the-art database applications. Its many enhancements have enabled programmers to develop programs impossible to accomplish in an interpreted environment.

We have consistently worked to improve the performance and capabilities of the product to ensure that Clipper users have the finest applications tool available for the microcomputer. We are committed to continue providing dBASE programmers with the capabilities they require to stay ahead of the pack.

For my part, I cannot say that my faith in reviews has been shaken because rarely have I seen a review that reflects a real insight into what the product does and how it is used. For the most part, the product reviewers are not involved in applications development. Again, if you want to find out about what Clipper can do for you, ask someone who really knows what they are talking about—a Clipper user.

Edward J. Brassard
Nantucket Corporation
Los Angeles, CA

Whereas some products are reviewed one at a time, we feel that in this case it was preferable to present in one article information on three products that address one need, although admittedly in somewhat different ways. The key point is that the review covered three products, not four—previously published results for dBASE III were included as a basis of comparison, not as a fourth alternative, and certainly not to suggest that dBASE III is preferable to any of the compilers. The purpose was to present information by which users could determine which one of them provides the best combination of the advantages a compiler has over an interpreter: execution speed, source code security, and cost of licensing end users.

I apologize for the erroneous statement in the conclusion of the article that Clipper programs run slower than the others; that comment was meant to apply only to disk-intensive operations. Of the 10 tests, Clipper tied for first in 2 and placed second in 4. In most operations, especially those with console interaction and computations in memory, Clipper is both measurably and noticeably faster than dBASE III.

Database operations were tested using the standard suite of benchmarks and on the same system used for every one of the data manager reviews. The results were confirmed by several operators on several different systems and were printed correctly. The code for the standard database tasks was written by Dave Browning for his review of dBASE III PLUS ("A Data Manager: The Evolving Standard," May 1986, p. 166). It is available for downloading from PCTECHline. But as Mr. Trimpop points out, disk operations are not the only consideration in real-world applications. In recognition of this fact, several additional tests were devised specifically to demonstrate those areas where compilers significantly outperform dBASE III PLUS. No set of benchmarks can adequately represent every possible, or even

the most common, real-world application. We show the results of a sufficient number of tests so that knowledgeable readers can estimate the performance under the conditions most prevalent in their own applications.

Finally, contrary to the impressions made on these two gentlemen, I did not find Clipper to be an inferior or unsatisfactory product. As the article plainly stated, all three are high-quality products, and the choice between them is difficult. I presented my choices, but also, I hope, enough facts to allow readers to reach their own conclusions.

—Ted Mirecki

PRINTERS' LAMENT

I thoroughly agree with Will Fastie's complaints about printers ("The Printer Standards Gulf," Directions, January 1987, p. 9), and I would like to add a few grievances of my own.

Today, every printer has a microprocessor and always knows exactly where the print head is. But if I want to know if a page has room for another paragraph, I must go to endless bother to keep track of the print head in my own program. Surely, in 1987, it would not be too much to expect that I could ask the printer for this information?

Likewise, it would not be difficult to punch a code pattern into the tractor feed strip, marking the top of the page, and specifying the paper size. This way, instead of peering into the printer looking for an almost invisible fold to see if someone has left the head halfway down the page, I could simply instruct the machine that if it were not at the top of the page, that it should go there, and report as such when it has.

I prefer the European 11⅔-inch A4 paper, but I can only tell my Epson that a page is so many inches, or lines, long, and this is not much help if I want to vary line spacing. It would be far more logical to specify everything in terms of feed increments, so that any size paper could be used. The same complaint applies to WordStar and Microsoft Word, which both insist on using a fixed increment. Users have endless hassles trying to mediate between a program that thinks in 1/48-inch units and a printer that feeds in 1/72-inch steps.

Finally, just to prove that I am hopelessly idealistic, could we not have a simple, properly designed, standard bidirectional parallel port for applications work such as this? At present we have the choice of the fiendishly complex and expensive IEEE-488, or the abominable RS-232—the only "standard" that ensures that an individual, unique cable will be required to connect any given piece of equipment to any other given piece of equipment.

R. H. Riordan
Cybec Electronics
East Brighton, Australia

COMMENT AT WILL

All letters to the editor should be directed to Editor, *PC Tech Journal*, Suite 800, 10480 Little Patuxent Parkway, Columbia, MD 21044. Correspondence also can be submitted over MCI Mail to PCTECH.

Although *PC Tech Journal* cannot publish every letter received, every effort is made to answer as many as possible. Please keep letters brief and to the point, and include name, mailing address, and telephone number; when a letter is lengthy, a diskette is appreciated.

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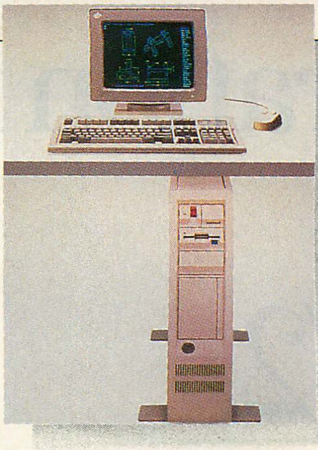
IBM Personal System/2 Model 30

IBM Personal System/2 Model 50

Personal System/2 Model 30 from IBM



80386-based IBM Personal System/2 Model 80

FROM IBM

An entire family of microcomputers has been announced by **IBM Corporation** as well as a host of peripheral products, options, and support packages. These other announcements are grouped according to category.

The **IBM Personal System/2** consists of four systems with a range of eight configurations, offering a variety of performance, memory, and storage options. All models use very large scale integration (VLSI) chips and surface-mount technology to provide increased function and reliability. The custom gate arrays are made from high-performance, cool-running CMOS with circuits as small as 1.5 microns. They include graphics, memory, and processor-support chips. The following are integrated on the system board: the diskette controller; parallel, serial, and pointing-device ports; keyboard and memory functions; and enhanced color and monochrome graphics capabilities. The System/2 family employs two types of 3½-inch diskette drives: one uses standard (720KB) diskettes, the other uses high-capacity (1.44MB) diskettes.

A new bus architecture, called the **Micro Channel**, is an IBM-exclusive feature of the 80286- and 80386-based System/2 models that handles more data, synchronizes the entry and exit of data and contributes to an increase in processing power between 2 and 3½ times the PC/AT. The Programmable Option Select function on the Micro Channel automatically configures all add-in boards, handles any conflicting addresses, and verifies that the boards are working properly—all without the need for manual switch settings. The Micro Channel enables up to 32 bits of data to flow to and from the processor; it supports up to 15 direct memory access (DMA) devices with faster data rates for greater application throughput.

Model 30, available in two configurations, is an 8-MHz, 8086-based system that runs 2½ times faster than the PC/XT. It comes standard with 640KB RAM and features the **Multicolor Graphics Array** (MCGA) enhanced graphics support. **Model 30-002** has two 720KB diskette drives, and **Model 30-021** has one 720KB diskette drive and one 20MB hard-disk drive. Three standard 8-bit PC-bus expansion slots are available. A socket on the system board accommodates an 8-MHz 8087. Model 30 incorporates a 64KB ROM for a start-up self test of system components, IBM BIOS support, and BASIC language interpreter. This system has a color graphics subsystem that supports text and graphics modes (8-by-16-dot character matrix, 256 colors in 300-by-200-pixel resolution, and 2-color graphics in 640-by-480 mode, all selected from a palette of more than 256,000 colors). Model 30-002, $1,695; Model 30-021, $2,295.

Model 50 is a 10-MHz, 80286-based desktop system with 1MB of RAM (expandable to 7MB) and features the **Video Graphics Array** (VGA), which has 12,750 gates and allows the choice of 16 colors in 640-by-480 mode and 256 colors (out of a possible 256,000) in 320-by-200 mode. Three 16-bit Micro Channel expansion slots are available. There is a socket on the system board for a 10-MHz 80287. Model 50 has one 1.44MB diskette drive and a 20MB hard disk. This system uses a 128KB ROM, and extra security features have been added to prevent tampering. $3,595.

Model 60 is similar to Model 50, but is available in two floor-standing configurations. **Model 60-041** has a 44MB hard disk, and **Model 60-071** has a 70MB hard disk. Both feature 1MB of RAM (expandable to 15MB) and one 1.44MB diskette drive. It has a socket on the system board for a 10-MHz 80287. Seven 16-bit Micro Channel expansion slots are available. Model 60-041, $5,295; Model 60-071, $6,295.

Model 80, built around the Intel 80386, is available in three floor-standing configurations. **Model 80-041** has a 16-MHz clock speed, 1MB RAM (expandable to 16MB), and a 44MB hard-disk drive. **Model 80-071** also runs at 16 MHz, but has 2MB RAM and a 70MB hard disk. **Model 80-111** also comes with 2MB RAM, but runs at 20 MHz and has a 115MB hard disk. All three have four 16-bit and three 32-bit Micro Channel expansion slots. A socket on each system board is available for the appropriate 16-MHz or 20-MHz 80387. Model 80-041, $6,996; Model 80-071, $8,495; Model 80-111, $10,995.

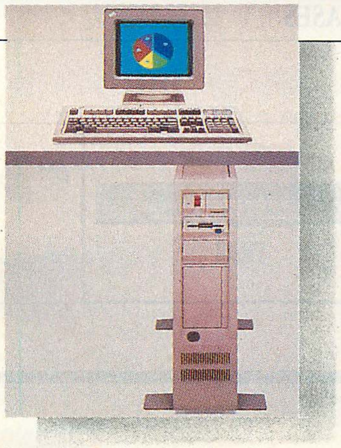
OPERATING SYSTEMS

IBM DOS version 3.3, available now, supports all of the System/2 models as well as the entire PC line. Features include several new commands as well as improved performance, additional communications ports, and support of multiple DOS partitions on a hard-disk. $120; upgrade, $75.

Jointly developed with Microsoft Corporation and scheduled for release in the first quarter of 1988, **IBM Operating System/2** (OS/2) will be a full-function operating system for Models 50, 60, and 80. Three types of application environments are supported by OS/2: DOS, Family, and OS/2. The DOS environment allows many existing DOS applications to run unaltered. The Family environment enables an application to begin to exploit the functional advantages of OS/2, while maintaining portability to DOS. The OS/2 environment allows the user to run multiple applications concurrently. Each application, individually or collectively, can use up to 16MB of available memory.

A built-in, graphics-based **Presentation Manager**, which supports graphics screens with windowing, allows the user to view multiple applications simultaneously. This program will be included in OS/2 version 1.1. OS/2 will be

IBM Personal System/2 Model 50



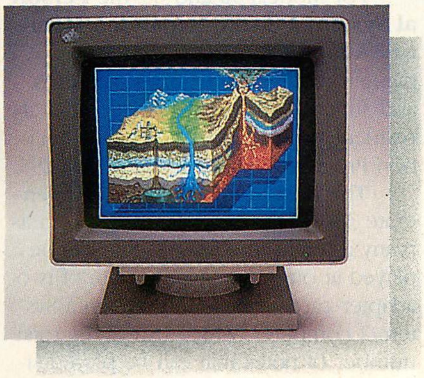
Personal System/2 Model 60 from IBM

available in a **Standard Edition** (without communications or database support) or in an **Extended Edition** (with an advanced relational database system and intersystem communications, connectivity, and terminal emulation). Standard Edition 1.0 and 1.1, $325 each; Technical Reference for 1.0 and 1.1, $200 each; Toolkit for 1.0 and 1.1, $750 each; Extended Edition, $795.

DISPLAYS

Each of the four analog displays available for the System/2 features higher-resolution characters and images on a non-glare, reduced-flicker screen. They are fully compatible with IBM CGA and EGA graphics modes.

The 12-inch **Monochrome Display Model 8503** features white and intensified-white characters against a black background or black characters against a white background. Model 8503 has the medium addressability of a 9-by-16-dot character matrix and a resolution of 720 by 400 pixels in text mode or 640 by 480 pixels in graphics mode. The 14-inch **Color Display 8512** is a stripe-pitch analog display that has the medium addressability of a 9-by-16-dot matrix with a resolution of 720 by 400



Color Display 8512 for IBM Personal System/2

pixels in text mode or 640 by 480 pixels in graphics mode. It can display 256 colors simultaneously from a palette of more than 256,000. The **Color Display 8513** is a 12-inch medium addressability analog color display. The 16-inch **Color Display 8514** is an analog color display that has the high addressability of both a 12-by-20-dot and a 7-by-15-dot matrix with 1,024-by-768-pixel resolution in both graphics and text modes. 8503, $250; 8512, $595; 8513, $685; 8514, $1,550.

The **Personal System/2 Display Adapter** raises the addressability of the Model 30 in text mode to a 9-by-16-dot character matrix, provides more colors for the other models, and enables connection of the new displays to be used on the PC family. $595.

The **Personal System/2 Display Adapter 8514/A** increases the functions of the Model 50, 60, or 80, and, when combined with its optional memory expansion, offers a palette of more than 256,000 colors with 256 supported on screen at a time and enhances performance in the 640-by-480-pixel graphics mode. It also allows the Monochrome Display 8503 to display up to 64 shades of gray at one time. $1,290.

CONNECTIVITY

The **Token-Ring Network Adapter/A** provides token-ring attachment for the System/2, transmitting and receiving at a speed of 4 million bits per second (Mbps). The adapter also provides up to 16KB RAM and all the function of the Token-Ring Network PC Adapter II at a lower price. $795.

The **8228-KT3 Token-Ring Network Starter Kit/A** consists of one access unit, four adapters, cable sets, software, and documentation. It allows set-up of a small pilot network of the new systems for testing and demonstration of several ring functions. $4,710.

The **PC Network-Broadband Adapter II** and **II/A** attach the Model 30 and PCs (II) as well as all other System/2 models (II/A) to the network and supports the Network BIOS (NetBIOS) and IEEE 802.2 protocols via the IBM LAN Support Program. $570 each.

The **PC Network-Baseband Adapter** and **Adapter/A** connect the PC and System/2 families to the PC Network Baseband, taking full advantage of the greater processing speeds of the 80286 and 80386. $470.

The **PC Network Baseband Extender** links as many as 80 workstations on standard IBM cabling over a minimum of 200 feet (for daisy chain topologies) up to a maximum of 800 feet (for star network topologies). $750.

ROLMphone 244PC is a voice- and data-communications telephone that attaches to the System/2 for modem-type access to public or private switched telephone networks. It supports the Hayes AT command set. Price is not available.

The **PC LAN version 1.2** provides file, print, and message function for PCs connected in a LAN and enables users to share program applications and databases across the network. $175.

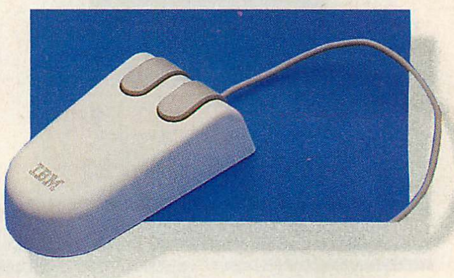
The **LAN Support Program** provides an IEEE 802.2 interface and a NetBIOS interface for the Token-Ring Network and the PC Network (Broad- and Baseband) and supports both new and existing adapters. $50.

The **LAN Manager version 1.0** enhances the network management capability of the Token-Ring Network and assists the user in problem determination and error recovery. As an application of NetView/PC, it can forward alerts to NetView running in a host and allows remote operation. $1,995.

The **Token-Ring Network Bridge Program version 1.1** passes bridge error information, forwards reports of configuration changes to the IBM LAN Manager, and extends the management capabilities across multiple token rings. $1,495.

The **PC Network Protocol Driver** is a NetBIOS programming interface for the IBM PC Network Adapter

IBM Personal System/2 3363 Optical Disk Drive



Mouse for IBM Personal System/2

Cards II and II/A and allows the new Network-Broadband adapters to communicate with adapters on existing networks. The program supports the NetBIOS interface with a maximum of 62 names and 64 sessions. $700.

The **IBM Local Area Network Asynchronous Connection Server Program** lets the IBM PC, System/2, and RT PC access asynchronous host computers from an IBM LAN. It also provides attachments to other asynchronous devices. $1,200.

The **3270 Connection** adapter card provides 3270 display station emulation with host file-transfer capability. Together with the **IBM 3270 Workstation Program versions 1.0** and **1.1**, the adapter card provides up to four host screen sessions, six PC-DOS application sessions, and two notepad functions for both PC and System/2 machines. The adapter card also may be attached to the Token-Ring Network and the PC Network. The 3270 Workstation Program 1.1 offers extended support. 3270 Connection, $595; 3270 Workstation Program 1.0 and 1.1, $495 each.

The **PC 3270 Emulation LAN Management Program version 1.0** provides a small, remote LAN, with network management from a central site. This program, which runs in an IBM 3270 Emulation Program gateway, monitors the LAN for failures and also provides automatic alert forwarding to a NetView host. $995.

The **IBM 3270 Emulation Program version 3.0** provides a wide variety of connectivity and communications configurations. This emulation program supports stand-alone, gateway, network station, and gateway/network station configurations. $995.

The **IBM 3278/79 Emulation Adapter** plugs into the PC, XT, AT, 3270 PC (both G and GX models), RT PC, and Model 30. Most, but not all, of the functions of the emulated displays are supported. $595.

The **IBM Enhanced 5250 Display Station Emulation Adapter**, along with the IBM Enhanced 5250 Emulation Program version 2.12, connects Model 30 (or any member of the PC family) to the IBM System/34, /36, or /38, while continuing to allow the execution of standard PC applications. Price is not available.

The **System/2 Multiprotocol Adapter/A** provides a full- or half-duplex multiprotocol serial data transmission channel and supports asynchronous, bisynchronous, HDLC, or SDLC protocols. The adapter supports modems or direct attachment, is programmable to 19,200 bits per second (bps), and allows automatic protocol switching via software at set-up. $296.

The **System/2 300/1200 Internal Modem/A** provides the capability to transmit data in duplex mode over Public Switched Telephone Network at 300 or 1200 bps and supports the Hayes AT command set. $395.

OPTIONS

Several products from IBM enable users to exchange data between the PC family (with 5¼-inch diskette drives) and the System/2 family (with 3½-inch diskette drives). A **3½-inch External** ($395) and **3½-inch Internal Diskette Drive** ($170) are immediately available for some models of the PC/AT and PC/XT. A **5¼-inch External Diskette Drive** ($335) has been announced for the System/2. An **IBM Data Migration** Facility ($33) uses standard printer cable to transfer data from a PC to the System/2 via the two parallel ports.

The **3363 Optical Disk Drive**, is a write-once, read-many (WORM) drive with a 200MB capacity. The 3363 is offered as an internal option on Models 60 and 80 and an external option for Models 30 and 50. $2,950.

The **6157 Tape Drive Adapter** supports attachment of the IBM 6157 Streaming Tape Drive to the System/2 for fast save/restore and data interchange capability. $350.

The **Personal System/2 Mouse** has two-buttons, attaches to the pointing-device port, and requires no additional power supply or hardware. $95.

An **8-MHz 8087** numeric coprocessor ($310), a **10-MHz 80287** ($525), and a **16-MHz 80387** ($795), and an **20-MHz 80387** ($1,195) are available for the appropriate System/2 models to perform high-speed arithmetic, logarithmic, and trigonometric operations.

Available for Model 30, as well as for the XT, AT, and 3270 PC, is the **2MB Expanded Memory Adapter**, which not only has 2MB of expanded memory, but also comes with a standard parallel printer port. When utilized with the 3270 PC Workstation Control Program version 1.0 or 1.1, it provides a solution for users who reach the 640KB limit of their system memory in executing large applications. The adapter provides expanded memory function for up to six concurrent DOS sessions, and the use of device drivers (expanded memory and virtual disk) to manipulate large amounts of data that expand the number of applications that can be run on base systems. $1,295.

For Models 50 and 60, the **Personal System/2 80286 Expanded Memory Adapter/A** provides 2MB of expanded memory function. It requires and supports the device drivers that are resident within the IBM 3270 Workstation Program version 1.0 or 1.1. $1,295.

The **IBM Music Feature** can generate 336 voices or instruments, with as many as eight instruments that can be played at one time. A maximum of two adapter cards can be installed in a System/2 computer, which brings the total number of notes that can be played simultaneously to 16. $495.

IBM Corporation, Information Systems Group, 900 King Street, Rye Brook, NY 10573; 800/426-2468

CIRCLE 351 ON READER SERVICE CARD

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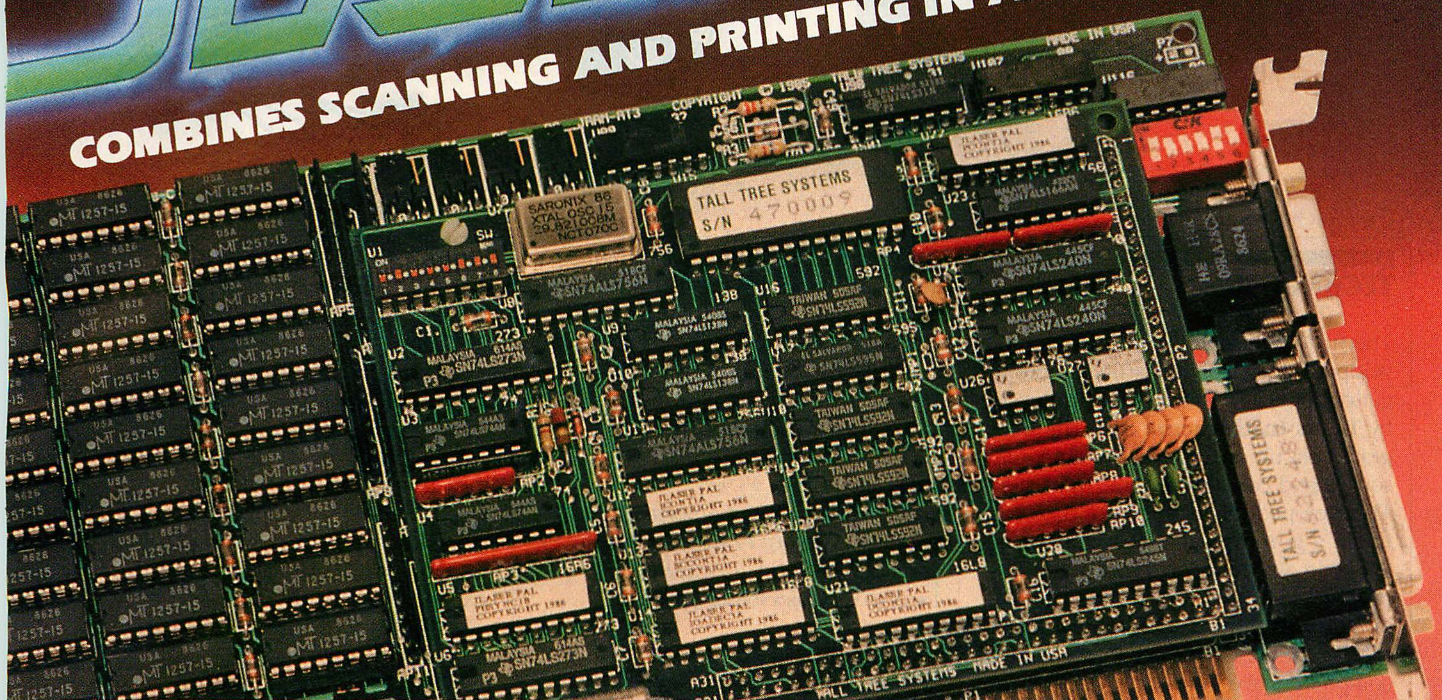
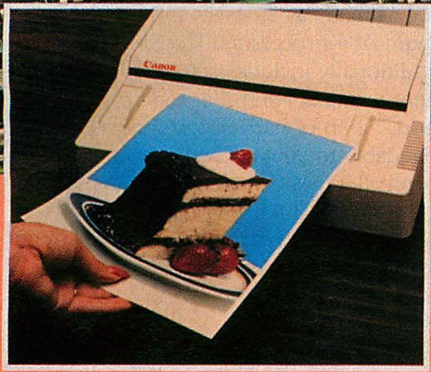
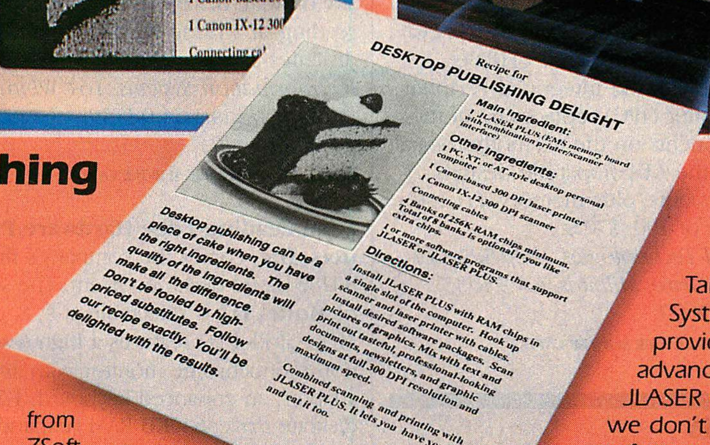






It makes desktop publishing a piece of cake!

Tall Tree Systems introduces another breakthrough in desktop publishing with JLASER PLUS. We've combined a 2 MB EMS memory board and an interface to both a Canon®-based laser printer and scanner. JLASER PLUS increases the performance of both devices and gives you a low-cost solution to the limitations you've been experiencing with them.

Furthermore, the same memory that is made available to your printer and scanner is also available for all your other conventional applications. You get system memory, expanded LIM memory, extended memory in an AT-type machine, RAM Disk and print spooler — all in a single slot!

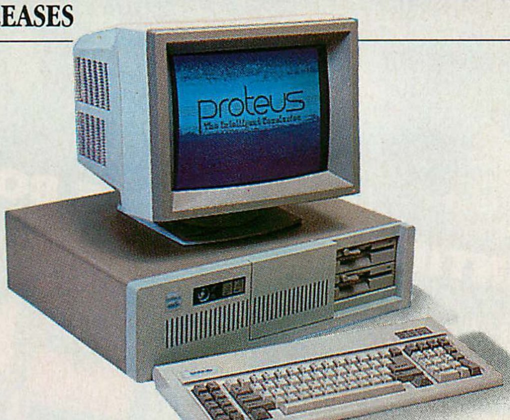
Supporting JLASER PLUS is a host of software packages, such as PC Paintbrush + from ZSoft, Dr. Halo D.P.E. from Media Cybernetics, LaserGL from Software Express, Ventura Publisher from Xerox, Page Builder from White Sciences, Le Print from Le Baugh Software, Fancy Font and Fancy Word from SoftCraft, Inc., and many more to be announced.

It takes a technological innovator like Tall Tree Systems to provide a major advancement like JLASER PLUS. And we don't stop at performance. We also deliver value, which is truly icing on the cake.

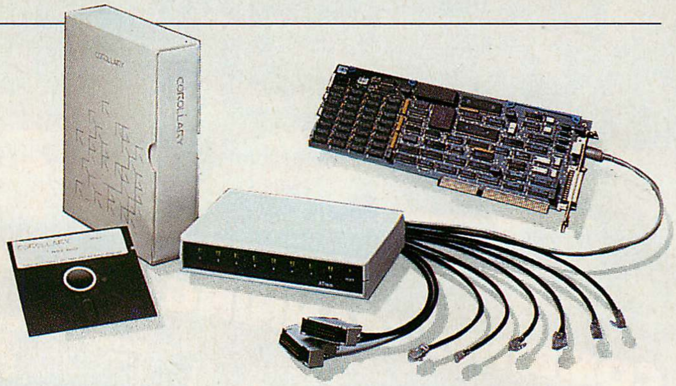
TALL TREE SYSTEMS
2585 E. Bayshore Road
Palo Alto, CA 94303
(415) 493-1980
Telex: 9102404041

CIRCLE NO. 194 ON READER SERVICE CARD

TALL TREE SYSTEMS



Proteus X-16 AT-compatible computer



ATtain subsystem from Corollary, Inc.

TECHNOLOGY

The first 32-bit microprocessor chip developed specifically for artificial intelligence applications has been produced by **Texas Instruments** (TI). The integrated circuit measures 1 centimeter square and contains 553,687 transistors. TI developed this LISP microprocessor under a government contract and is developing a production version, the **Explorer LISP**. This version will be used in future Explorer and defense systems to provide greater power than symbolic computers have today.
Texas Instruments, Data Systems Group, P.O. Box 809063, DSG-104, Dallas, TX 75380-9063; 800/527-3500;
CIRCLE 309 ON READER SERVICE CARD

A 12.5-MHz version of the AT-compatible CHIPset has been introduced by **Chips and Technologies, Inc.** The **12.5-MHz PC/AT CHIPSet** (CS8220-12) has the same pin-out as the 8-MHz PC/AT CHIPSet. The five-chip CHIPSet, combined with the Integrated Peripherals Controller (IPC) replaces 67 of the 94 components on the AT motherboard, reducing the AT-compatible designs to 27 components, plus memory. Price for a quantity of 100, $70.50.
Chips and Technologies, Inc., 521 Cottonwood Drive, Milpitas, CA 95035; 408/434-0600
CIRCLE 310 ON READER SERVICE CARD

SYSTEMS

A 16-MHz, AT-compatible computer, the **Proteus X-16**, has been introduced by **Proteus Technology Corporation**. The Proteus comes standard with 1MB RAM (expandable to 4MB on the motherboard using additional memory chips), eight I/O slots, a 16-MHz Intel 80286, a socket for the 80287, a diskette/hard-disk drive controller, a 200-watt, 110/220-volt power supply, three serial and two parallel ports built onto the motherboard, one 1.2MB and one 360KB diskette drive (or a 3½-inch internal diskette drive can replace the 360KB drive at no additional charge), and an enhanced keyboard. X-16, $2,945; with added 40MB hard disk and 40MB tape drive, $3,995.
Proteus Technology Corporation, 377 Route 17, Airport 17 Center, Hasbrouck Heights, NJ 07604; 201/288-8629
CIRCLE 301 ON READER SERVICE CARD

A 10-MHz, 80286-based system, the **JC LIPS III/286**, is an AT compatible from **JC Information Systems**. JC LIPS III/286 operates at 8 or 10 MHz with a 12-MHz upgrade to be offered later. The computer has eight slots, a coprocessor socket, two serial ports and one parallel port, an enhanced keyboard, and .5MB RAM (which is expandable to 1MB on the motherboard). A 5¼-inch, high-density diskette drive that is capable of reading or writing 1.2MB or 360KB diskettes also is included. $1,495.
JC Information Systems, 161 Whitney Place, Fremont, CA 94539; 415/659-8440
CIRCLE 303 ON READER SERVICE CARD

From **Leading Edge Hardware Products, Inc.** comes the company's first 80286-based desktop system. The speed of **Model D2** is selectable at 6, 8, or 10 MHz. Model D2 features a high-resolution monochrome monitor with an EGA adapter, an enhanced keyboard, 1.2MB diskette drive, 640KB RAM (expandable to 1MB on the motherboard), and six expansion slots. $1,936.
Leading Edge Hardware Products, Inc., 225 Turnpike Street, Canton, MA 02021; 617/828-8150
CIRCLE 304 ON READER SERVICE CARD

Three multiuser systems have been released by **Gulfstream Micro Systems**. Each system comes with 1MB RAM (expandable to 15MB), one parallel port, a 360KB diskette drive, a 60MB streaming-tape drive, one terminal, and XENIX.

The 80286-based **SM 286/12** supports 12 users, includes five serial ports, and has 36MB of hard-disk storage (expandable to 256MB).

The 80386-based **SM 386/20** supports up to 20 users. The entry-level configuration also includes an 8-port intelligent terminal controller, two parallel ports, and 72MB hard-disk storage (expandable to 600MB).

The **SM 286/34**, an 80286-based multiprocessor using the Multibus I architecture system, is capable of supporting as many as 34 users and a maximum of 4 processors. The SM 286/34 additionally includes a 16-port intelligent terminal controller, one parallel port, 72MB of hard-disk storage (expandable to 900MB) with a caching disk controller. SM 286/12, $7,585; SM 386/20, $16,695; SM 286/34, $24,995.
Gulfstream Micro Systems, 1065 S. Rogers Circle, Boca Raton, FL 33431; 800/443-0500; in Florida, 305/994-6500
CIRCLE 305 ON READER SERVICE CARD

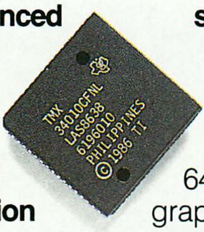
A multiprocessor subsystem from **Corollary, Inc.** enables an AT running XENIX to support as maximum of 32 terminals. The **ATtain** subsystem package consists of a single-slot 80286, a special ATtain extended XENIX kernel, and an optional terminal concentrator unit designed to support eight terminals. Up to four ATtain subsystems can be installed in a single PC/AT to build a 32-user system. Each ATtain 286 Processor module has an 8-MHz 80286, 1MB of dual-ported zero-wait-state RAM, and two serial ports. The ATtain extended kernel, derived from Microsoft XENIX source code, serves as a replacement for the standard XENIX kernel object code. It operates with all standard XENIX utilities, commands, and applications, and offers true multiprocessor

CIRCLE READER SERVICE NO. 200 FOR FACING AD

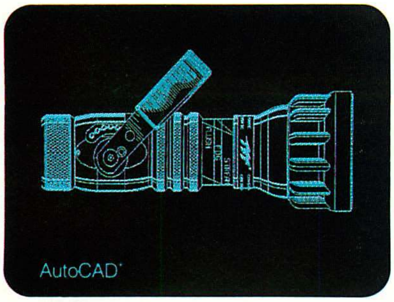

TEKTRONIX NEW
ADVANCED PC GRAPHICS
STANDS ALONE.
AERODYNAMIC HEATING
EQUILIBRIUM TEMPERATURE
CONE SECTION
CYLINDRICAL SECTION
TEMPERATURE
DISTANCE
TIME
IBM

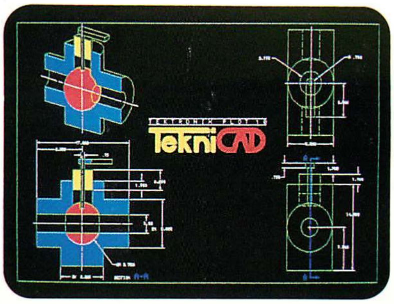
BECAUSE IT WORKS TOGETHER.

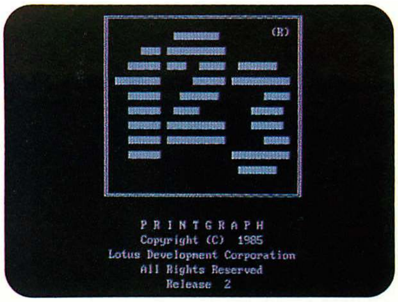
Introducing Tek Advanced PC Graphics: a fully integrated system of high-performance graphics, easy system connectivity, and unparalleled application software for your PC. Tek Advanced PC Graphics starts with a flexible multiple-rate color graphics monitor that provides 640x480 Tektronix-style graphics as well as EGA and CGA software compatibility.



Driving your monitor to a whole new level of graphics speed is Tek's PC4100 graphics coprocessor board. It features Texas Instruments® powerful TMS 34010 32-bit





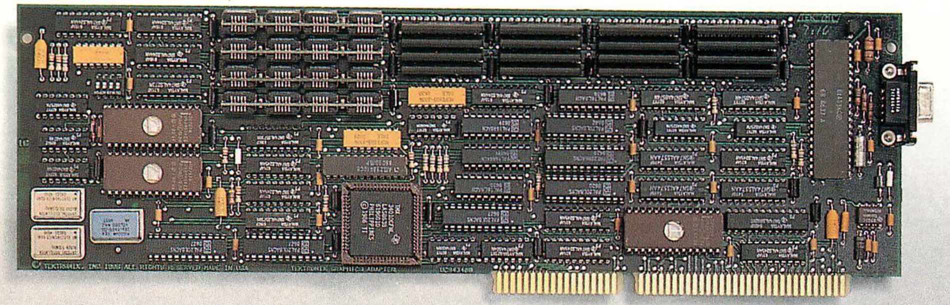


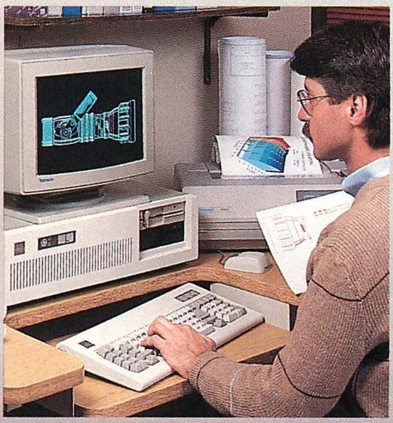
Graphics System Processor for ultra-fast throughput of your design applications. Add to that Tek's PC-05 or PC-07 terminal emulation software, and you're ready for stand-alone computing or access to a world of mainframe graphics.

To bring those applications to life, you can connect a Tek color ink-jet printer. And start producing high-resolution, vibrant hardcopy output on either paper or transparencies.

Couple all that with Tektronix worldwide support and service, and your PC can gain the same productive advantages that host-based systems in scientific and engineering environments have had for close to two decades.

Tek's PC4100 graphics coprocessor board delivers serious graphics on a stand-alone basis. Built around the Texas Instruments Graphics System Processor(GSP),™ the graphics coprocessor board achieves a combination of sophisticated graphics and fast throughput your PC just couldn't deliver before. The GSP assumes the complete graphics processing workload, freeing your PC processor for other requirements.





New companion monitor brings together fine detail and maximum flexibility. You'll view your applications on Tek's new multiple-rate monitor. In true Tek tradition, it provides ideally balanced, 640x480 addressability and a 60 Hz non-interlaced refresh rate. So you can use advanced packages like AutoCAD,® Zenographic's Mirage™ and VersaCAD.®

Then, to move from GSP graphics to emulation of the IBM® Enhanced Graphics Adapter(EGA) mode, you simply soft-switch. And you're ready to run the popular PC packages you probably already use in CGA/EGA mode—standards like Lotus® 1-2-3,® Microsoft® WORD® and Microsoft® Windows,® to name just a few.

Last, but not least, Tek's PC4100 links you to a world of mainframe graphics. All you do is load Tek PC-05/PC-07.

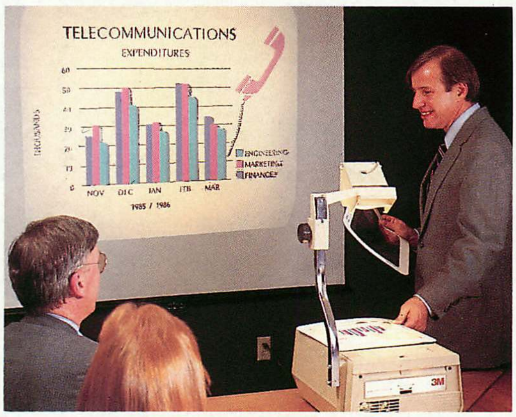
Tek PC-05/PC-07 terminal emulation software gives you mainframe accessibility with the local processing power of your PC. Because Tek PC-05 and PC-07 terminal emulation software runs under MS-DOS® 2.0 and higher, you can run your mainframe-based

AND SETS YOU APART.

applications software on your PC as if it were a Tek 4105 or 4107 terminal.

Which means you can quickly access the power of Tek graphics—including 4107 segments, true zoom and pan, rubberbanding, definition of up to 64 viewports and more. You can use these highly productive features with a wide range of well-known designer software packages such as ISSCO's DISSPLA® and TELL-A-GRAF,® MCS's ANVIL-5000,™ SAS Institute Inc.'s SAS/GRAPH, Precision Visuals' DI-3000,® Swanson Analysis Systems' ANSYS® and McNeal-Schwendler's NASTRAN.

In addition, you can utilize software development tool sets like Tektronix PLOT 10® GKS, IGL, TCS and STI software as well as numerous driver support packages created for the 4105 and 4107.



Completing the picture: perfect color output with Tek's reliable ink-jet printers. At the push of a button, the Tek 4696 lets you produce exacting color reproductions of your on-screen display on either paper or transparencies.

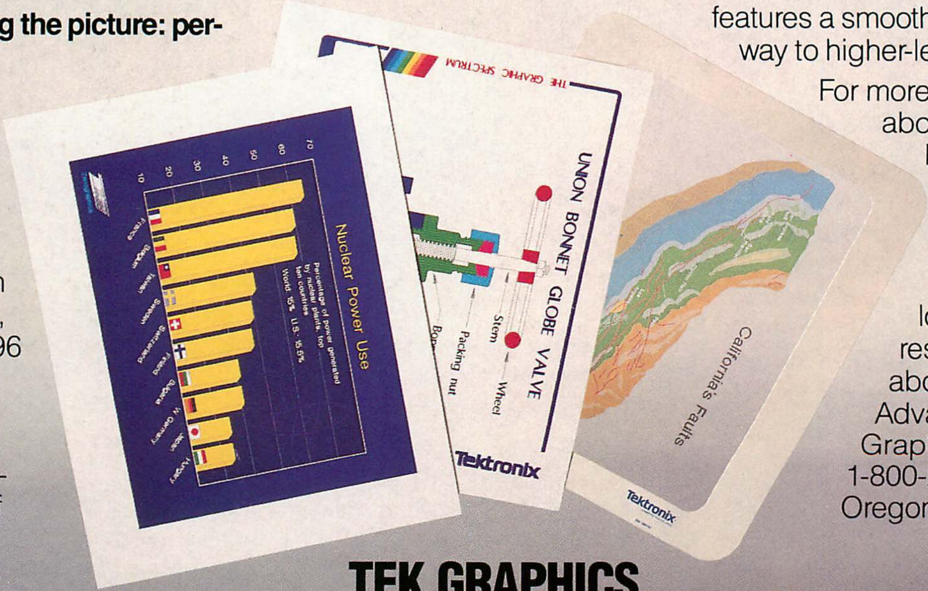
Because of its 120 dots per inch addressability in both horizontal and vertical directions, you can achieve resolution of up to 1280 points x 960 points per "A" size image.

All the key tools for software development, right from the outset. The new Tektronix Graphics Interface™ (TGI) for the PC provides the basics of Tek graphics functionality to application programs running under MS-DOS. What's more, in-circuit emulator, C-compiler, assembler and linker are all available from Texas Instruments to help software developers write applications packages for the PC4100 graphics coprocessor board.

To enable sufficient workspace for custom interfaces or specific application programs, the PC4100 graphics coprocessor board comes standard with a full megabyte of program memory.

Put yourself on the sure path of Tek graphics evolution. Whether you choose Tek PC stand-alone graphics, Tek's high-resolution monitor, Tek terminal emulation or all three, you can be assured Tek will keep you current with the best and most productive graphics. Because like all our products, Tek Advanced PC Graphics features a smooth built-in pathway to higher-level graphics.

For more information about how Tek lets you stand alone and work together, contact your local Tek representative about Tek Advanced PC Graphics. Or call, 1-800-225-5434. In Oregon, 1-235-7202.



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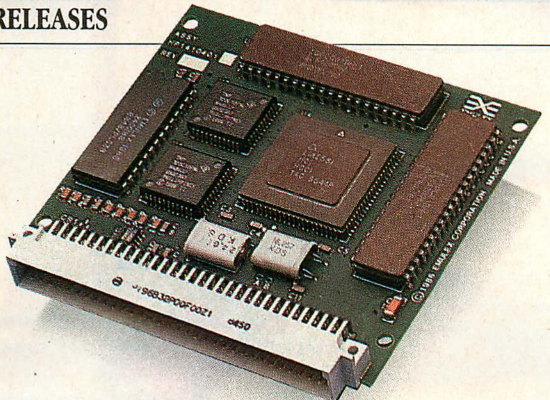


Emulex HP144 modem data pump

80286-based CS-4220 from Cordata Corporation

scheduling, load balancing, and resource allocation. Other features include a 230-Kbaud serial port that serves as a communications link with an optional Corollary Terminal Concentrator. The CMOS microprocessor-based Terminal Concentrator allows eight RS-232 terminals to be connected to an ATtain Processor. No setting of switches or jumpers is required at installation. ATtain 286 Processor, $1950; ATtain extended kernel, $250; Corollary Terminal Concentrator; $750.
Corollary, Inc., 18011/E Skypark Circle, P.O. Box 18977, Irvine, CA 92713; 714/250-4040
CIRCLE 307 ON READER SERVICE CARD

Two entry-level AT compatibles are available from **Cordata Technologies, Inc.** Based on the Intel 80286, the **Cordata Systems 4200 Series** of slim-line desktop personal computers feature a small footprint of 18.25 by 16 inches and operates at a speed of 8 MHz with one wait state. The **CS-4210** comes standard with two half-height 360KB diskette drives, and the **CS-4220** has a half-height 20MB hard disk with the controller configured on the motherboard. Both models have 640KB RAM, built-in clock/calendars, serial and parallel ports and a socket for an optional 80287. CS-4210, $1,695; CS-4220, $2,195.
Cordata Technologies, Inc., 275 E. Hillcrest Drive, Thousand Oaks, CA 91360; 805/375-1500
CIRCLE 302 ON READER SERVICE CARD

CONNECTIONS

Proteon, Inc. has announced the availability of **VINES**, a virtual networking system from **Banyan Systems, Inc.** VINES is a network server for Proteon's 4-Mbps ProNET-4 token-ring network. ProNET-4 network conforms to the IBM Token-Ring Network implementations, as well as the IEEE 802.5 standard, so VINES users can mix ProNET-4 and IBM Token-Ring PC Adapter interfaces on the same VINES network. Banyan's VINES operates with Proteon's ProNET-4 p1340 hardware interface in a PC and with the ProNET-4 p1344 interface in an AT. These interfaces also plug into the Banyan Network Servers (BNSs) to support a high-performance, file-server-based networking system. Banyan VINES/286 software for ProNET (p5713), $1,895; Banyan/BNS, $14,995 to $21,995; Banyan/DTS desktop server, $9,995 to $16,995; ProNET-4 support for existing BNSs that support ProNET-10, $1,000.
Proteon, Inc., Two Technology Drive, Westborough, MA 01581-5008; 617/898-2800
CIRCLE 311 ON READER SERVICE CARD
Banyan Systems, Inc., 135 Flanders Road, Westborough, MA 01581; 617/366-6681
CIRCLE 312 ON READER SERVICE CARD

A network interface from **Proteon, Inc.** that complies with the IEEE 802.5 standard has been developed for the p4200 Gateway. Designated the **p4210**, this interface is an addition to Proteon's product line of multiprotocol, multinetwork routers. The p4210 network interface plugs into the p4200 Gateway, which supports ProNET-4, -10, and -80 (4-, 10-, and 80-Mbps token-ring networks), Ethernet, ARPANET, T1, and 56-Kbps wide area networks. The gateway can operate these various interfaces simultaneously while supporting most communications protocols. Only one Proteon Gateway is required for multiprotocol networking freedom. The gateway's network interfaces support any combination of communications media including fiber optics, infrared, microwave, coaxial, twisted pair, or the IBM Cabling System. $3,590.
Proteon, Inc., Two Technology Drive, Westborough, MA 01581-5008; 617/898-2800
CIRCLE 313 ON READER SERVICE CARD

Emulex Corporation has entered the host-independent, data communications marketplace with two product announcements. The **HP144** and **HP96** are compact, low-power consuming, high-speed modem data pumps that operate at top data speeds of 14,400 bps and 9,600 bps respectively. Intended for use by OEMs who require full-duplex, four-wire, leased-line modem function and occasional half-duplex, dial-backup operation, these completely CMOS-based modems can use dedicated, unconditioned lines or operate over the general, switched telephone network. The HP144 and HP96 modem pumps feature CCITT V.33 standard compatibility with automatic equalization, programmable tone-generation, diagnostic capability, and loopback test capabilities. The HP144 modem data pump is CCITT V.33 compatible and operates at 14,400 bps using eight-state, Trellis-coded modulation. The 12,000-bps fallback mode specified by CCITT V.33 is also provided. The HP144 supports the use of in-band signaling during modem training to identify the chosen option, interleaving up to six channels of time division multiplexed (TDM) data 2,400 to 12,000 bps in accordance with CCITT V.33. HP144, $700; HP96, $365.
Emulex Corporation, 3545 Harbor Blvd., P.O. Box 6725, Costa Mesa, CA 92626; 714/662-5600
CIRCLE 315 ON READER SERVICE CARD

A high-performance Ethernet hardware interface for networks using Advanced NetWare LAN operating systems software is available from **Novell, Inc.** The **NetWare E-Net adapter**, which uses an eight-bit bus, includes an on-board transceiver that allows connection to either thick or thin Ethernet cabling configurations. Taking advantage of low-power CMOS chips, the board reduces power consumption and fits on a half-sized card. The NetWare E-Net is available for network file servers and PC

RELAY Silver from VM Personal Computing

Battery-powered Pocket Modem MM1200 from Migent

LAN workstations. It is compatible with other Ethernet adapters offered by Novell, including the 3COM 3C505, 3COM 3C501, InterLAN NP600A, and InterLAN 5010. Although the E-Net uses a different driver, all boards can coexist on the same NetWare network. The E-Net makes use of the National Semiconductor's DP8390 Network Interface Controller, 8KB of high-speed RAM for buffer storage, and direct memory access to and from the 8088-based machines. It uses string I/O in 80286-based machines for fast data transfer to the host machine's memory. $495.
Novell, Inc., 122 E. 1700 S, Provo, UT 84601; 800/453-1267; in Utah, 801/379-5900
CIRCLE 316 ON READER SERVICE CARD

A PC-compatible facsimile (FAX) board manufactured by **Gulfstream Micro Systems** can send and receive documents to and from any Group III FAX machine communicating at 9600 bps (bits per second). **EZ-Fax** can transmit an average page of text in 15 seconds over normal dial-up telephone facilities anywhere in the world. EZ-Fax hardware consists of a serial port, a scanner port, a telephone port, and a speaker for call-progress monitoring.

EZ-Fax software consists of two programs. One, the EZ-Fax Communications Manager, is a multitasking program that provides background capabilities, such as transmitting and receiving; conversion from ASCII to FAX, FAX to printer, and FAX to Graphic Display concurrent with transmit, receive, and scan; and printer spooling. The second program, EZ-Fax File Manager, is windows oriented and has foreground capabilities, such as sending of ASCII files, paper (scanned) files, or graphic files; defining and maintaining the EZ-Dial directory; allowing scheduled events and prior activity to be viewed; performing installation configuration; and giving printer definitions.

Options for EZ-Fax include: **EZ-Code**, a coding program that incorporates the National Bureau of Standards Data Encryption Standard; **EZ-Data**, a 300/1200-bps, Hayes-compatible data modem on a piggyback board; and **EZ-Scan**, a 300-dpi (dots per inch) desktop scanner that reads hard-copy documents. EZ-Fax, $1,495; EZ-Code, $195; EZ-Data, $129; EZ-Scan, $895.
Gulfstream Micro Systems, 1065 S. Rogers Circle, Boca Raton, FL 33431; 800/443-0500; in Florida, 305/994-6500
CIRCLE 318 ON READER SERVICE CARD

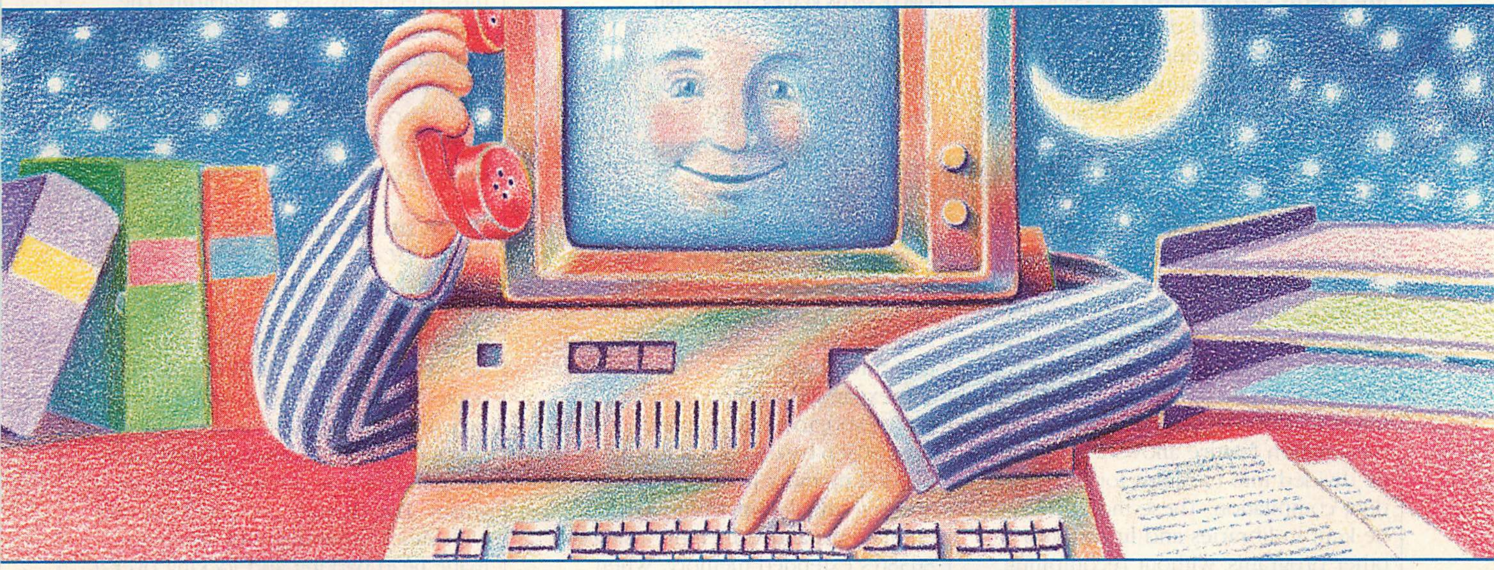
An addition to the family of communications programs from **VM Personal Computing** has been announced. **RELAY Silver** includes a script language with learn mode, memory-resident operation, and an Application Program Interface (API). Menu-driven operation and context-sensitive help are available, yet advanced users can bypass menus or make the software totally command driven. The memory-resident operation allows the user to send and receive files simultaneously while other DOS applications are being run. RELAY Silver supports the XMODEM and Kermit protocols as well as the bidirectional RELAY protocol. RELAY Silver has all of the advanced features currently found in VM's RELAY Gold except for the capability of communication with VM's mainframe software. RELAY Silver $150; upgrade from RELAY to RELAY Silver, $40.
VM Personal Computing, 41 Kenosia Avenue, Danbury, CT 06810; 800/222-8672; in Connecticut, 203/798-3800
CIRCLE 322 ON READER SERVICE CARD

The family of StarLAN local area network products from **Western Digital Corporation** (WD) has been enlarged with the introduction of **StarCard PLUS**, a PC adapter card (conforming to the IEEE 802.3 1BASE5 standard) that provides a network station interface to the 1-Mbps StarLAN network. It connects the computer to the StarLAN network at any StarLAN-compatible hub, such as WD's 10-port StarHub and can operate with WD's StarCard and StarLink products on the same network. It has a shared memory interface, a dual-ported 8KB memory that can be accessed directly by the PC without PC direct memory access channels. StarCard PLUS runs with a wide selection of network software. Drivers are provided for its ViaNet software and Novell's Advanced Netware. The NetBIOS/OSI Interface Program supports applications such as Torus Tapestry, Microsoft MS-NET, and the IBM PC Network. The board operates in PCs with system clocks as fast as 16 MHz.

Also introduced was the **EtherCard PLUS**, WD's first Ethernet/Thin Ethernet PC adapter board that has an architecture in common with the StarCard PLUS and can use the same LAN operating system drivers. StarCard PLUS, $299; EtherCard PLUS, $399.
Western Digital Corporation, 2445 McCabe Way, Irvine, CA 92714; 714/863-0102
CIRCLE 319 ON READER SERVICE CARD

An external, battery-powered modem has been released by **Migent, Inc.** The **Pocket-Modem MM1200** measures 1.3 by 2.5 by 5.0 inches, weighs 9 ounces, and mounts directly to the serial port of the PC. Operating at 300 or 1200 bps (bits per second), the MM1200 is compatible with both the Hayes AT and Bell 212 command sets. The Pocket-Modem has surface-mount technology; non-volatile, 28-character memory; dual phone jacks; busy-signal and dial-tone monitoring; remote ring and tone sensing; and audible, low-battery indication via the PC speaker. The MM1200 has neither a DIP-switch configuration nor a power switch (the modem turns off automatically when the computer is turned off).

NIGHT SHIFT



While you're asleep, your PC application can transfer a day's worth of data files to your IBM mainframe. And while you're awake, Attachmate's Application Program Interface (API) does even more, including fast log-on/log-off, multiple sessions, custom user screens, and security.

If MIS programming backlogs are slowing down your production, our API will breathe new life into old mainframe applications with fresh user interfaces and screens.

All this under a secure, IBM compatible umbrella. In fact, Attachmate software, including API, will run on your existing IBM coax and SDLC adapters.

Discover the most powerful 3270 connectivity products ever made for the PC. Discover Attachmate.

Our *Quick Reference Guide for Micro-Mainframe Communications* has a handy competitive comparison chart. Call for your free copy today.

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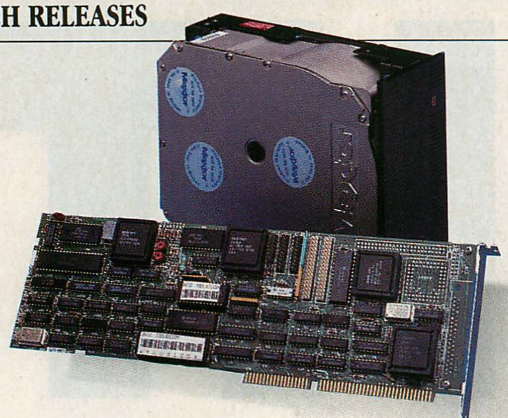

ACS Telecom 10-Disk/386 file-server expansion kit

COREtape and CT60E tape drive from CORE International

The Migent Pocket-Modem comes complete with communications software and user's guide. $259.
Migent, Inc., 865 Tahoe Blvd., P.O. Box, 6062, Incline Village, NV 89450-6062; 702/832-3700
CIRCLE 314 ON READER SERVICE CARD

SOFTWARE DEVELOPMENT

Shipment has begun on **version 3.0** of the **QuickBASIC Compiler** from **Microsoft Corporation**. Version 3.0 offers an improved debugging environment, new extensions to the BASIC language, and in-line support for the 8087 and 80287. CodeView, an enhanced debugger offered with Microsoft C and FORTRAN compilers, is now included with QuickBASIC. Version 3.0 supports named constants. Execution speeds for floating point and graphics has been increased. QuickBASIC 3.0 keeps track of all errors found during a compilation. Afterward, the cursor is placed on the first error. The QuickBASIC editor is integrated with the compiler and supports insert and overtype modes. A separate compilation feature allows a program to be divided into modules for independent compilation. These modules can be kept in libraries and linked into other programs, without recompiling. $99; upgrade, $30.
Microsoft Customer Service, 16011 N.E. 36th Way, P.O. Box 97017, Redmond, WA 98073-9717; 800/426-9400; in Washington, 206/882-8088
CIRCLE 326 ON READER SERVICE CARD

A specific version of the **UNIX System V** operating system for Intel's 80386 has been announced jointly by **AT&T** and **Microsoft Corporation**. The product will incorporate Microsoft's XENIX System V compatibility into AT&T's UNIX System V release for 80386-based machines. It will be distributed under AT&T's trademarked name—UNIX—and will be available in early 1988. AT&T will continue to market UNIX System V and Microsoft will continue to market XENIX System V during development of the 80386 implementation. Applications written for Microsoft's XENIX System V and for UNIX System V will run on the implementation for the 80386 without any modification required.
AT&T, Data Systems Division, 100 Southgate Parkway, Morristown, NJ 07960; 800/247-1212; in New Jersey, 201/898-8000
CIRCLE 329 ON READER SERVICE CARD
Microsoft Corporation, 16011 N.E. 36th Way, P.O. Box 97017, Redmond, WA 98073-9717; 800/426-9400; in Washington, 206/882-8088
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A software-based expanded memory manager for 80386-based PCs is available from **Quarterdeck Office Systems**. The **Quarterdeck Expanded Memory Manager-386** (QEMM) enables users of software programs that take advantage of the Lotus/Intel/Microsoft expanded memory specification (LIM EMS), to access expanded memory on a 80386-based PC without an expanded memory board. QEMM uses the 80386's virtual-86 machine mode to emulate expanded memory using the 80386's extended memory. When QEMM is used with Quarterdeck's DESQview multitasking environment, a user can run a maximum of nine programs that all use expanded memory for data simultaneously. $59.95.
Quarterdeck Office Systems, 150 Pico Blvd., Santa Monica, CA 90405; 213/392-9851
CIRCLE 328 ON READER SERVICE CARD

PERIPHERALS

A file-server expansion kit for the Compaq Deskpro 386 has been released by **ACS Telecom**. Designed for compatibility with leading LANs, the **10-Disk/386** expansion kit increases the storage capacity and speed of the Deskpro 386. The 10-Disk/386 system can add up to 630MB of hard-disk storage to the Deskpro 386. With a 10-Mbps data transfer rate, a 1-to-1 interleave factor, and lower disk-access times, these expansion drives are designed to increase processing speed. The expansion kit also uses up to 8MB of high-speed, 32-bit, static-column RAM to cache most disk-read requests with an intelligent most-frequently-used algorithm. The system is compatible with the built-in Compaq controller, for a combined total of 760MB. Prices start at $5,595.
ACS Telecom, 25825 Eshelman Avenue, Lomita, CA 90717; 213/325-3055
CIRCLE 308 ON READER SERVICE CARD

CORE International has introduced, **CORE HC40**, a 40MB ESDI $5\frac{1}{4}$-inch hard-disk drive with an average access time of 10 milliseconds and a data transfer rate as fast as 800KB per second when using a **CORE HC Series** controller. These speeds are achieved by using voice coil technology with a fast actuator. For accuracy the HC40 is designed with an advanced servo mechanism. The HC40 is protected not only with shock mounting, but also automatic head parking and locking over a dedicated landing zone.

An external version of its COREtape backup system, the **CT-60E**, also has been announced by CORE. This unit incorporates features for portability—small size ($5\frac{7}{8}$ by $10\frac{15}{16}$ by $3\frac{1}{8}$ inches), light weight (4.5 pounds), and a built-in handle. Optional controller cards are available that make multiple machine backups possible. The CT-60E uses one 62-pin cable for data and control signals as well as the power connection. With this one-cable solution, an additional power supply is unnecessary, allowing the unit to reduce its fan noise and weight. The COREtape software is

Toshiba's XM-2000 CD-ROM optical drive

DataFlex revision 2.2 from Data Access Corporation

compatible with XENIX, DOS, and Novell 286 2.0A, and backs up in either image or file-by-file and will do a file-by-file restore of an image backup. A catalog option allows the user to back up single files, complete or partial directories, or single files from multiple directories. HC40, $2,995; HC Series controller, $545; CT-60E, $1,595.
CORE International, 7171 N. Federal Highway, Boca Raton, FL 33431; 305/997-6055
CIRCLE 341 ON READER SERVICE CARD

The Disk Products Division of **Toshiba America, Inc.** has developed the **XM-2000**, a CD-ROM optical drive that features both audio and digital capability and up to 680MB of storage capacity. The XM-2000 delivers data with a fast average access time of 240 milliseconds using a voice coil actuator, which replaces the more conventional (and slower) DC motor found in audio CD products. High densities are achieved by allowing a continuous spiral groove with only 1.6-millimeter spacing between adjacent tracks. The recording surface is sealed by a protective coating, thus the information is virtually indestructible. Available in OEM quantities.
Toshiba America, Inc., Disk Products Division, 3910 Freedom Circle, Suite 103, Santa Clara, CA 95054; 408/727-3939
CIRCLE 340 ON READER SERVICE CARD

From **Hewlett-Packard** (HP) comes a 20-page-per-minute, advanced paper-handling laser printer that is targeted for multiuser environments and features increased graphics memory with 34 internal fonts. The **HP LaserJet 2000** printer series is available in three configurations. **Model 2684A** has the following features: it is compatible with the HP Printer Command Language (PCL); it comes standard with 1.5MB RAM, full-page, 300-dpi (dots per inch) raster graphics; and it contains two 250-sheet input bins and a 1,500-sheet, correct-order output bin. **Model 2684P** has the same features as the 2684A, plus a third paper-input bin that holds 2,000 sheets of 8½-inch or European A4 paper. **Model 2684D** has the same features as the 2684P, plus automatic two-sided (duplex) printing. All three models have a monthly print volume of 70,000 pages. RS-232/422, Centronics, and Dataproducts' Short Line and Long Line interfaces are available. The standard RAM of the HP LaserJet 2000 is expandable in 1MB increments up to a total of 5.5MB. A number of special symbol sets (such as mathematical, scientific, and international) are available for the different typefaces and type sizes (ranging from 8-point to 14-point). The HP LaserJet 2000 can support three different HP LaserJet printer cartridge fonts simultaneously as well as all HP LaserJet downloadable soft fonts and electronic forms. Model 2684A, $19,995; 2684P, $21,495; 2684D, $24,995; 1MB add-on memory module, $750.
Inquiries Manager, Hewlett-Packard, 1820 Embarcadero Road, Palo Alto, CA 94303; 800/367-4772
CIRCLE 335 ON READER SERVICE CARD

A parallel processor (80188) that runs as fast as 10 MHz and allows any two independent software applications to be run simultaneously has been created by **I-Bus**. The **IQ188** runs DOS 3.0 or 3.1 software, provides up to 1MB of dual-ported RAM, and functions as a hard-disk controller that can be accessed by the PC or the IQ188 processor. Batch multitasking and interactive windowing environments are fully supported. Processing capabilities can be expanded with additional cards. A hard disk of up to 32MB can be attached to the IQ188's controller, and each processor can access this memory. Two serial ports on the IQ188 operate at 34.8 Kbps and support SDLC/HDLC/SNA bit-synchronous communications protocols. It also has one parallel port and a battery-backed clock/calendar, which can be accessed by the PC's main processor. 256KB, $1,345; 1MB, $1,495.
I-Bus, 5730 Chesapeake Court, San Diego, CA 92123; 800/328-4229; in California, 619/569-0646
CIRCLE 342 ON READER SERVICE CARD

DATA MANAGEMENT

The multiuser applications development database system from **Data Access Corporation** has been revised. **DataFlex revision 2.2** features window-like screen-handling techniques that allow the user to create pop-up help screens, data-entry forms within other data-entry forms, and user prompts. An added command allows a DataFlex program's execution to be interrupted while an operating-system-level command is executed; upon completion of the external command or program, DataFlex is resumed from the point of suspension. The revision 2.2 update has a reduced compilation time and an improved REINDEX program for better performance in creating and maintaining indexes. Internally defined integer variables have been expanded from two bytes to four bytes. A utility has been added, called DB-READ, that converts DBASE data files to DataFlex data files and creates a DataFlex data-entry program to handle multiuser database maintenence. For single-user PCs and XENIX systems, $995; for LAN and multiuser configurations, $1,250; for UNIX and VAX/VMS computers, $1,800 to $8,000.
Data Access Corporation, 8525 S.W. 129th Terrace, Miami, FL 33156; 305/238-0012
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The material that appears in Tech Releases is based on vendor-supplied information. These products have not been reviewed by the PC Tech Journal *editorial staff.*

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- EXE File Header Utility.

C Benchmarks In seconds

	Microsoft C 4.0	Lattice C 3.0	Computer Innovation C 2.3	Aztec C86 3.2	Wizard C 3.0
Sieve of Eratosthenes (register)	82.9	151.4	172.3	88.0	91.9
Copy Block	86.9	231.7	199.0	123.8	189.5

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you've ever seen.

both at the same time. Open a window to view CPU registers and flags. Watch local and global variables as well. All while your program is running.

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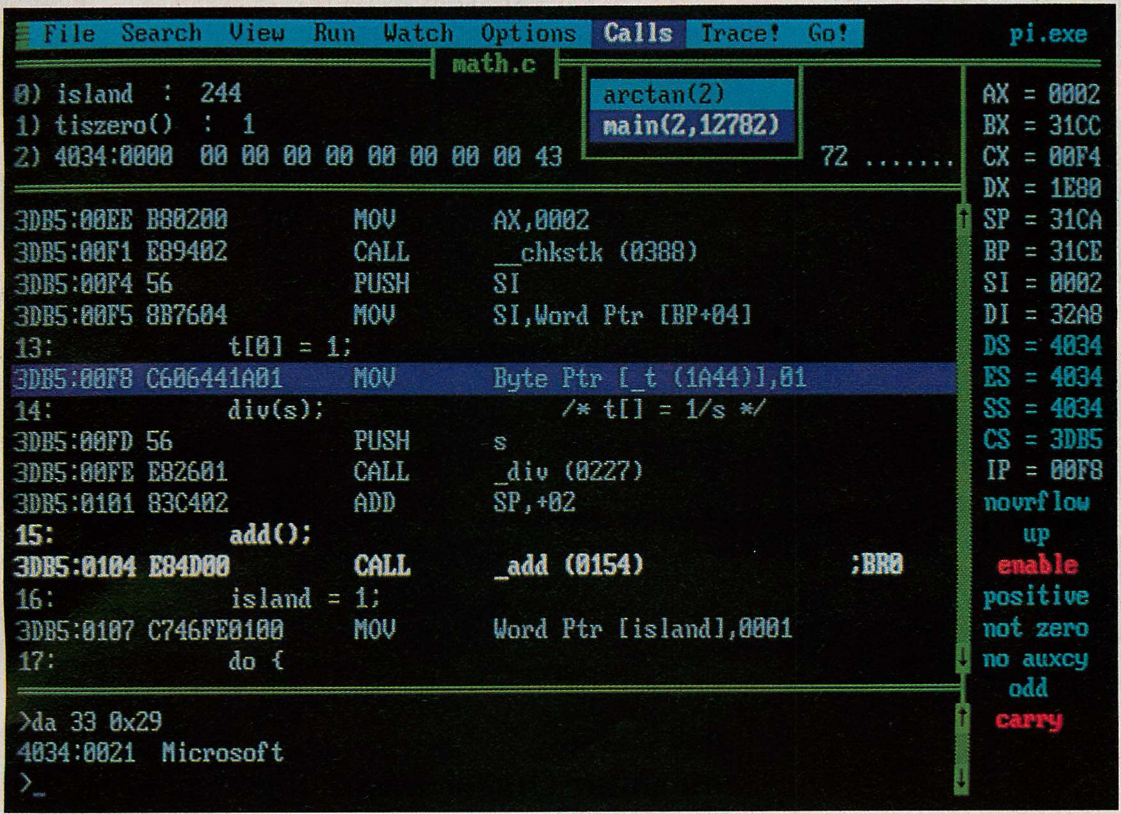

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CIRCLE NO. 140 ON READER SERVICE CARD

Join Us in September in San Diego to Tackle the Tough Systems Issues

Announcing the First Annual PC Tech Journal Systems Forum

IBM Changes the Rules Again!

IBM challenges users and vendors alike to change what have become industry-standard computers and an industry-standard operating system. Whether or not you like the PS/2 workstations and now think you may need the undelivered benefits of the OS/2 operating system, your computer buying, development, and integration decisions will be affected by IBM's calculated risk.

What may have been prudent hardware and software decisions in March of 1987, may become dangerous by July. If you are involved in the selection, integration, and development of desktop computer products—particularly, if you operate in a connected environment—you probably have already begun to rethink your computing options for 1987 and beyond.

IBM has made a bid to recapture its market share by establishing new standards for desktop computing with higher performance machines and a new operating system (OS/2) with promised multitasking, multiuser capabilities, as well as integrated communications and an integrated SQL-compatible database.

Do You Need to Follow the Leader?

If AI/XT class machines and PC-DOS are soon to become obsolete, should you look beyond IBM for other advanced technology solutions? What about the Macintosh? What about UNIX—after all, it's already multiuser and multitasking?

What About Applications Development in a Changing Environment?

Desktop workstations will be at the heart of an increasingly complex applications development environment with different operating systems, different hardware systems, and an increasing need to link both like and unlike machines and software.

Moreover, applications are being built with powerful new tools: object-oriented/AI languages, desktop-based data management software. Are traditional programming languages—COBOL, FORTRAN, BASIC, and so on—ultimately doomed?

Can successful micro-based DBMS products migrate to the mainframe/mini universe or will the mainframe heavyweights such as Cullinet, Cincom, Oracle, etc. shove them aside as their own products migrate to the desktop computer?

The Systems Forum Brings User, Developer, and Integrator Organizations Together to Sort Through These Tough Systems Issues

Hundreds of members of the corporate computer community will join with manufacturers, developers, resellers, and consultants to tackle the tough issues in no-holds-barred panel discussions and audience question-and-answer sessions. You also will have plenty of time to talk informally with your peers who are building, integrating, and maintaining complex hardware and software systems. You can talk to the vendors whose products you are trying to make work, or which you may be considering for purchase.

Panel Discussions Will be Timely, Technical, Relevant, and Lively

Panel topics focus on real world problems that demand solutions. Your users, your clients, and your vendors share concerns about the best way to build, buy, and integrate desktop workstations within a connected environment. Stand alone issues are fading as multiuser and multitasking hardware and software reach the desktop. Here are some of the issues we'll be tackling:

1. *The PS/2: Rebirth of the IBM Standard.*

A horde of systems integration issues surround IBM's PS/2 workstations thanks to its new microchannel bus, its new graphics standard, and its 3½ inch diskette. Out with the old and in with the new? What is the short-term and long-term added value of the PS/2. Are clones still a viable alternative? What can add-on vendors add on?

2. *OS/2: Operating system of the 1990s?*

Is OS/2 the desktop operating system you've really been waiting for? Is it fast enough? Is multitasking enough? Will the compatibility box suffice for hundreds of DOS applications? Will new OS/2 applications offer enough value to justify an expensive conversion? Can you afford to wait until 1988 for release 1.0.

3. *The Macintosh: The Resurgence of an alternative standard.*

Has the Mac become a logical desktop choice in the corporate world? Do its new 32-bit architecture, open design, windowing, and inherent friendliness already exceed what's being promised by IBM and Microsoft for 1988 and beyond? Is IBM compatibility essential as long as you can communicate? Is Apple the only microcomputer vendor not hurt by IBM's new machines?

4. *UNIX: Not just for Techies anymore!*

It may be big and it may be complex, but it's already multiuser and multitasking—and its available now. On an 80386 machine equipped with UNIX do you really have an ideal platform for a host of workstation applications? Is UNIX the most intelligent applications bridge between unlike machines (no need to wait for APPC and LU 6.2)?

5. *Applications Development: Beyond 3rd Generation toward AI.*

Just how different are the new object-oriented/AI languages from COBOL, FORTRAN, C, BASIC, etc.? Are LISP, PROLOG, etc. necessary for expert systems? How are user companies building AI/expert system applications?

6. *Developing Applications in a Multiuser/Multivendor Environment.*

How do you build an application that must reside on more than one type and size of machine? What parts should fit where? How do you optimize performance in a connected environment? What is the ultimate developer's workstation?

7. *Optimizing LAN Performance.*

Getting acceptable performance from a local area network involves much more than hooking up the cables and installing the network software. Careful LAN selection is the first critical step and depends on the number and type of users, the intended applications, and the extent to which gateways and bridges are required. Once those choices are made, LAN tuning is critical.

8. *Linking Unlike Machines.*

IBM PC with PC-DOS to IBM PS/2 with OS/2 to IBM 370 with MVS to DEC VAX with UNIX to Macintosh to a 3-COM network to a Novell network. Making these kinds of connections is increasingly necessary—but still hazy after all these years. People, computers, data, and applications are widely distributed. IBM has some theoretical, announced and planned solutions—APPC, LU 6.2, SAA, SNA, and OS/2 extensions—but what are users and vendors doing right now to make the connections? What's blue sky and what's real world?

9. *Database Management on LANs.*

In principle, the number of MIPS available on the server and on individual desktops should yield impressive data management capabilities—rivaling multiuser micros, minis, and some mainframes. In fact, LAN and DBMS product limitations have greatly reduced the potential power of networked data management applications. What can you do right now to maximize DBMS performance? What new releases and new products will eliminate performance roadblocks?

10. *The Desktop-based DBMS as Production Database.*

Most PC-based data/file-management software in user hands is lightly used, if at all—and primarily as a simple file manager or decision support tool. But the best of the current database management products offer multifile/multiuser/transaction-processing capabilities. For companies of all sizes the potential exists to build powerful production applications with data management software that reside on PCs. Which products are worth considering? What are the limitations? What must be added to even the best DBMS products to give them full transaction-processing capability?

Panelists will include members of both the vendor and user community chosen for technical competence and real world experience—professionals like you. Here's a partial list of panelists already committed to participating in the SYSTEMS FORUM:

From User Organizations:

- Steve Ikard, Mgr. Advanced Systems Grp., Wells Fargo Bank
- Laurie Antonell, Dir. Systems and LANS, Merrill Lynch, Capital Mkts. Div.
- Mike Johnson, PC Systems Mgr., PC Systems Support Grp., Transok, Inc.
- Dr. James Nestor, Sr. Mgr. R&D, Ernst & Whinney

From Manufacturer/Publisher Organizations:

- Philippe Kahn, Pres., Borland Intl.
- William Casey, Div-Vice Pres., Product Architecture, Cullinet Software Corp.
- Alan Ashton, Pres., Word Perfect Corp.
- Steve Ballmer, Vice Pres., Microsoft Corp.
- Craig Burton, Vice Pres.-Mktg., Novell
- Safi Qureshey, Pres. & CEO, AST Research
- Chuck Hickey, Pres., Microport Systems, Inc.
- Peter Gabel, Pres., Arity
- Nat Goldhaber, Pres., Centram Corp.

From VAR/Reseller/Consultant Organizations:

- Mark Freund, Vice-Pres., Interconnect
- Rick Watkins, Co-Founder, Accelerated Learning Center

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TECH NOTEBOOK 77

ED VOLKSTORF

Batch File Interaction

A batch file can be programmed to interact with the user and then branch based on the response given.

Many DOS batch files would be more useful if they had the capability to interact with the user by issuing prompts and modifying the path of execution based on the responses. Because batch files already have the capability for conditional branching, a level of interaction can be created by setting appropriate conditions based on keyboard input. In its simplest form, this can be accomplished by executing the following program from a batch file:

```
MOV  AH,1    ; Standard input function
INT  21H     ; Call DOS, get character in AL
MOV  AH,4CH  ; Function to exit with return code
INT  21H     ; Call DOS to exit
```

The standard-input function reads a character from standard input. If the keyboard is the standard-input device and no character is present in the keyboard buffer, the branching program waits until a key is pressed. The ASCII code of the character is returned as an exit code. When the program exits, the batch file tests the code and branches on its value via an IF ERRORLEVEL statement.

For practical use, this simple program can be enhanced in three ways. It can display any text from its command line as a prompt. Extended scan codes can be returned for non-ASCII keys, such as the cursor control and function keys. Finally, alphabetic input can be converted to uppercase so that the batch file's response is not sensitive to the case of the user's input. An enhanced program, ASKKEY.ASM, is shown in listing 1. It should be assembled, linked, and converted to a .COM file with the DOS utility, EXE2BIN.

The ASKKEY program does not interpret the user's input; the batch file that calls it does that. An example of its use is given in ASKDEMO.BAT (listing 2). The batch file proceeds along one of two paths, depending on whether the user types Y or N, with all other characters rejected. The definition of which characters are accepted and which are rejected is made in the batch file and not in the ASKKEY program.

In the batch file, the user must properly construct the sequence of tests of the returned code. The ERRORLEVEL condition is true for return codes equal to or greater than the value in the IF statement. Recognizing two nonconsecutive characters requires four tests: for characters above the higher one, for the higher acceptable character, for characters between the two valid ones, and finally for the lower acceptable character. All other characters result in execution falling through to the error routine.

Ed Volkstorf is a configuration manager with the Planning Research Corporation, which is located in Virginia Beach, Virginia.

LISTING 1: ASKKEY.ASM

```
; ASKKEY - Display text and accept a char from Standard Input.
;          Return the ASCII code of the char as an ERRORLEVEL.
Code       Segment
           Org      0100H
           Assume   CS:Code, DS:Code
AskKey     Proc     Far
Begin:     Mov      SI,81H        ; SI -> 1st cmd line char
; Display all text in the command line up to 0DH (Carridge Return)
NxtChar:   Mov      DL,[SI]       ; get char from command line
           Cmp      DL,0DH        ; CR char means end of string
           Je       GetChar       ; Goto input mode if at end
           Mov      AH,02H        ; Standard Output function
           Int      21H           ; call DOS to output char
           Inc      SI            ; increment to next char
           Jmp      NxtChar       ; and go get it
; Accept a single character response from Standard Input
GetChar:   Mov      AH,01H        ; Standard Input function
           Int      21H           ; Call DOS, get char into AL
           Cmp      AL,0          ; extended character?
           Je       GetChar       ; Yes, get the scan code
           Cmp      AL,'a'        ; is char less than 'a' ?
           Jb       Xit           ; Yes, skip case change
           Cmp      AL,'z'        ; is it greater than 'z' ?
           Ja       Xit           ; Yes, bypass case change
           And      AL,NOT 20H    ; change to upper case
; Return to DOS with the RETCODE set
Xit:       Mov      AH,4CH        ; Set exit function
           Int      21H           ; call DOS to leave
                                  ; AL already has RETCODE
AskKey     Endp
Code       Ends
           End      Begin
```

LISTING 2: ASKDEMO.BAT

```
REM ASKKEY test
ECHO OFF
:GETKEY
ASKKEY Press Y or N
Rem Error if above 'Y'
IF ERRORLEVEL 90 GOTO ERROR
Rem Ok if = 'Y'
IF ERRORLEVEL 89 GOTO YES
Rem Error if Above 'N', below 'Y'
IF ERRORLEVEL 79 GOTO ERROR
Rem OK if = 'N'
IF ERRORLEVEL 78 GOTO NO
Rem Else fall into error
:ERROR
ECHO Wrong key pressed. Try again
GOTO GETKEY
:YES
ECHO Option "YES" was selected
GOTO EXIT
:NO
ECHO Option "NO" was selected
:EXIT
ECHO ASKKEY test completed.
```

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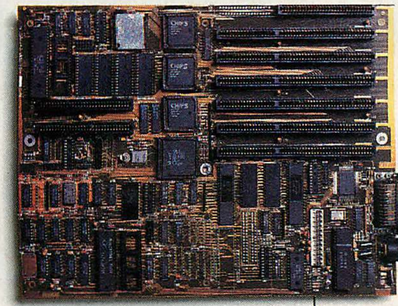

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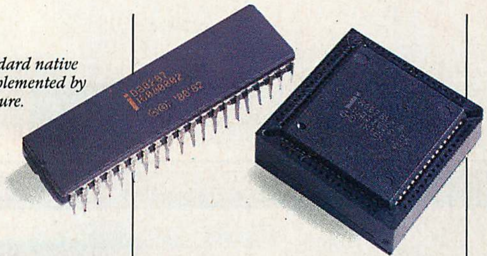

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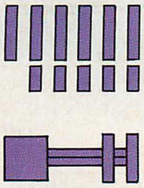

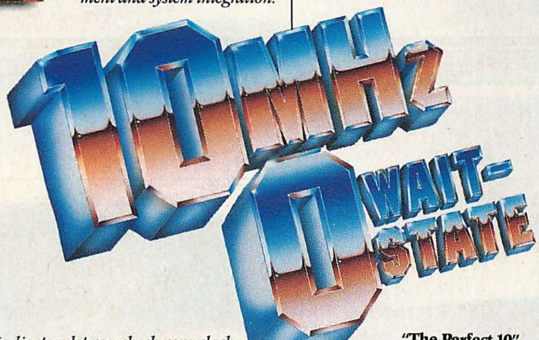

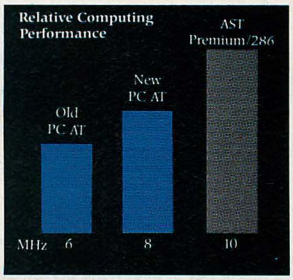

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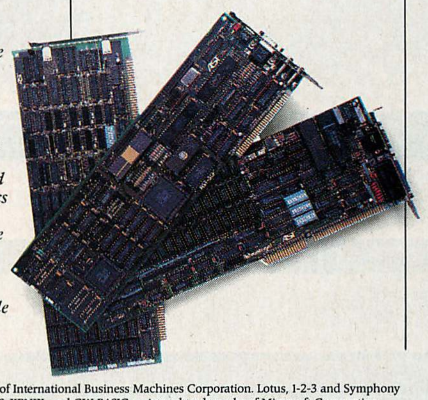

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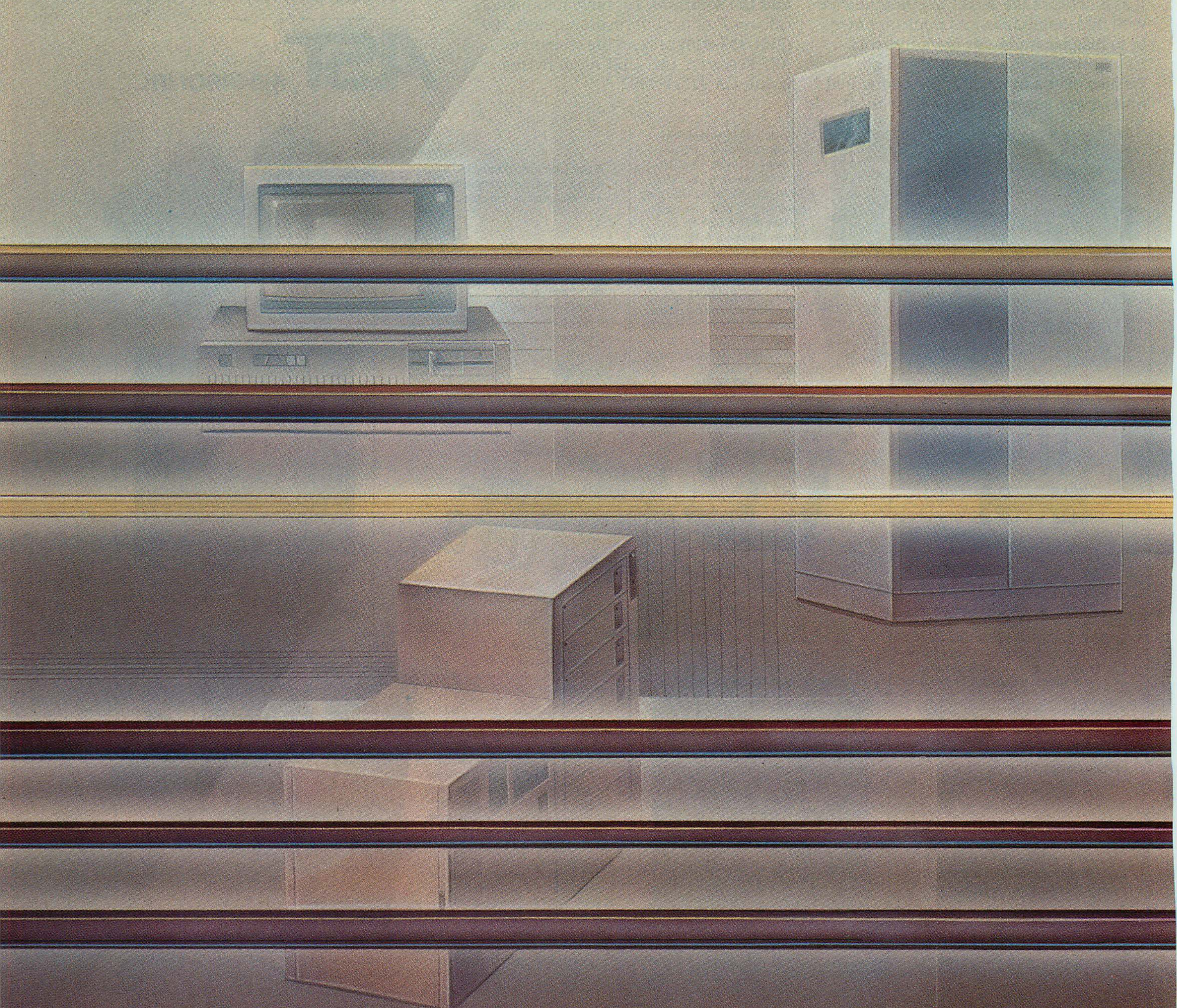
LAN Hardware Standards



The myriad network options available has been brought under control by a set of flexible standards for the prevalent hardware protocols.

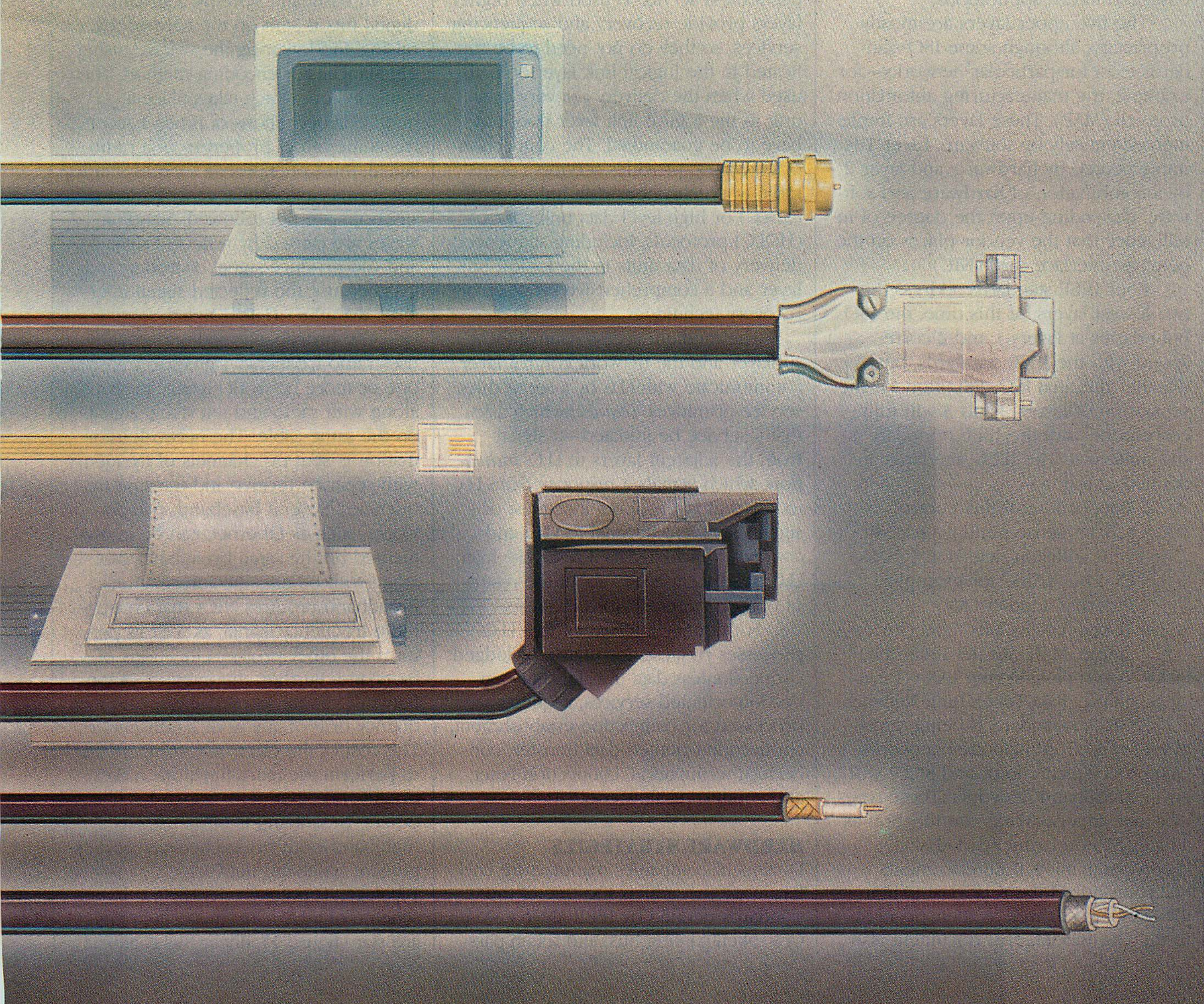
ART KRUMREY and
JOHN KOLMAN

As local area networks have proliferated, the need for standards has become evident. Dozens of hardware interfaces, topologies, and cable types, as well as network control programs and operating systems that run on different hardware are available. Because considerations such as wiring plans, network size, and cost-versus-performance vary greatly, it is unlikely and even undesirable that a single LAN standard could exist.

Instead, groups from the Institute of Electrical and Electronic Engineers (IEEE) and American National Standards Institute (ANSI), with representatives from many companies, have written a family of specifications for LAN hardware. Formal definitions for networks such as Xerox's Ethernet, AT&T's StarLAN, and the IBM Token-Ring Network are included. These standards, in addition to the de facto ARCnet standard developed by Datapoint, enjoy a large measure of multivendor support.

Unlike its earlier dominance in setting internal hardware and software standards for desktop computers, IBM has been slower to participate in the development of universal communications standards. Its competitors, however, have been in the forefront in applying their own standards to PC connectivity, particularly in LANs.

ILLUSTRATION • ANDY LEVINE



Today, most manufacturers are settling on one of three LAN hardware standards, formalized by ANSI and IEEE; selecting software is a separate decision. The designer and installer must understand these LAN standards and their role in building a network in order to figure out all the options.

IT ALL STARTS WITH OSI

In late 1981, formal liaison was established between the IEEE and the European Computer Manufacturers Association (ECMA), and the result was the stated objective that all standards should be in accordance with the open system interconnection (OSI) reference model of the International Standards Organization (ISO). The seven layers of the OSI model are listed in table 1. Layers 1 (physical control) and 2 (logical link control and medium access control) are the ones treated by IEEE standards. Layer 1 dictates what type of cable is used, and this can be the LAN design decision that most affects installation costs and future applications.

The five upper layers are mostly proprietary, although some ISO standards exist for particular networks—for example, the manufacturing automation protocol (MAP). These layers are implemented entirely by software. Layer 1 is implemented by hardware, and layer 2 by a combination of hardware and software, depending upon the degree of intelligence that the vendor places on the network interface card (NIC).

Four IEEE standards address the two lowest layers. At this time, the ISO boundaries at layers 1 and 2 correspond with the IEEE standards, but whether the final ISO definition for the separation of layers 2 and 3 will fully correspond with the IEEE boundary is still unknown. The IEEE standards are defined as follows:

802.2 Data or logical link control
802.3 Carrier sense multiple access with collision detection (CSMA/CD) bus LANs (for example, Ethernet and StarLAN)
802.4 Token-passing bus LANs (for example, MAP; ARCnet is similar)
802.5 Token-passing ring LANs (for example, IBM Token-Ring Network)

An 802.6 standard is being developed for metropolitan area networks using CATV technology, and 802.7 will cover broadband networks. These types of wider area networks can function as a bridge to departmental LANs.

A companion IEEE document, 802.1, describes the relationship among the standards as well as their position in the OSI model. This document also covers the relationship of the 802 standards to higher-layer protocols and treats network management and communications between networks.

TABLE 1: *OSI Model and IEEE 802 Standards*

LAYER	ISO MODEL DESCRIPTION	IEEE STANDARD
7	Application	N/A
6	Presentation control	N/A
5	Session control	N/A
4	Transport end-to-end control	N/A
3	Network control	N/A
2	Logical link control	802.2
	Medium access control (MAC)	802.3, 802.4, 802.5
1	Physical control	802.3, 802.4, 802.5

The IEEE 802 LAN standards deal with the implementation of layers 1 and 2 of the OSI reference model. Logical link control (802.2) is common to all media.

The upper part of the ISO's layer 2 corresponds to the IEEE's 802.2 standard, logical link control (LLC). LLC can be either connectionless (class I) or connection-oriented (class II). The connectionless service is used when higher layers provide recovery and sequencing services, so they do not need to be replicated in the logical link layer. It is also used when the delivery of every data unit in the logical link layer does not have to be guaranteed. The connection-oriented LLC provides services comparable to synchronous data link control (SDLC) or high-level data link control (HDLC) protocols, including sequenced delivery of data units in the logical link layer and a comprehensive set of error recovery techniques.

The medium access control (MAC) sublayer and the network control layer communicate with LLC by a set of three service primitives: *request*, which asks that a service be initiated—a signal from the adjacent layers to LLC; *indication*, which signals a response from LLC to adjacent layers about a request or signals an event internal to LLC; and *confirm*, which signals a response from LLC to adjacent layers about the results of one or more previous requests.

For connectionless services LLC processes requests for unacknowledged connectionless data transfer. For connection-oriented services, requests are processed for connection establishment, connection-oriented data transfer, connection termination, connection reset, and connection flow control.

HARDWARE STRATEGIES

Dozens of companies manufacture LAN hardware that adheres to one of the standards defined by IEEE/ANSI: CSMA/CD, token-passing bus, and token-passing ring. The selection of a LAN hardware standard involves seven factors: (1) transmission medium; (2) topology; (3) line access method; (4) speed; (5) cable type; (6) geographic span; and (7) address size.

Transmission medium. Two types of signaling methods can be used along the LAN cable: baseband and broadband.

In baseband systems, a stream of digital bits is sent on the network by raising and lowering the voltage, using the Manchester encoding method. The transmission, which takes place at hundreds of millions of times a second, has some of the properties of a radio signal; thus, phenomena such as standing waves can occur if cable length restrictions are not followed. Standing waves are caused by reflected signals and can produce signal distortion and loss because the reflected signal interferes with the original signal.

The broadband medium actually uses radio frequency signals to transmit one or more network signals, perhaps along with radio and television signals on the same cable. The network information is sent on channels of frequency with separate receive and transmit frequencies. Several baseband-style networks, such as Ethernet, can be implemented on the same broadband cable along with other radio information. Broadband requires NICs that create a radio frequency signal, as well as perform the other protocol functions of baseband. Further, the integrity of the network can be jeopardized by the frequency drift of any node's transmitter. The cost of the electronic components to perform the extra functions makes broadband NICs more expensive than others. Broadband is often used as a high-bandwidth bridge between less expensive baseband networks.

Topology. Topology refers to the layout scheme of a LAN. The major topologies are star (figure 1), linear bus (figure 2),

and ring (figure 3). Each of these topologies can be defined two ways: *logical topology* is the method by which the networked workstations contend for the media and pass messages; *physical topology* is the actual physical manner in which the workstations are wired. In general, the 802 standards address the logical topology and electrical interface issues within the network, leaving the physical wiring choices to the vendor.

In the pure (logical and physical) star topology, cable is arranged in the shape of a star, radiating from a central point—usually the server. Each cable to the server is unique; none is shared. Thus, the impact of a cable fault or NIC is limited to a single station. Because star networks have no shared resource, such as a bus, no complex protocol for sharing is needed, and none is defined by the IEEE. Most star implementations have, in fact, been proprietary. The major disadvantage of the star topology is that it requires a lot of cable.

The linear bus topology has a single length of cable, called the bus, or trunk. Every device is connected to the bus and the ends are terminated—not connected to each other. Usually the devices are connected to the main cable by *stubs*. In a typical configuration, the main cable is in the ceiling or wire channel and the stubs run to the workstation. Stubs are strictly limited in distance; for example, Ethernet's limit is six feet. Some variations, such as ARCnet, allow spurs from the bus, as long as the cable does not loop. Repeaters allow segments of cable to be connected by another medium—for example, fiber optic extensions of Ethernet.

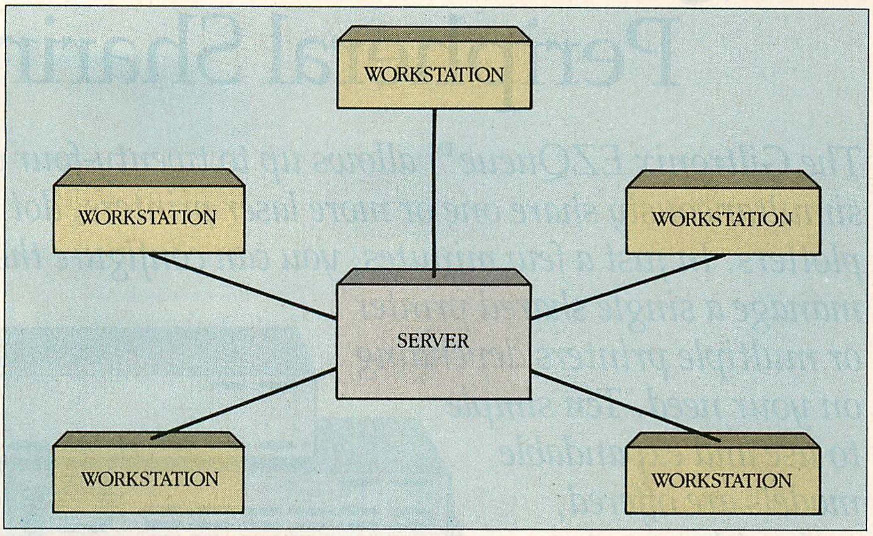
The bus has the advantage of wiring simplicity, but any break in the cable can cause the entire network, or entire segment of a network with repeaters, to fail. The total failure is caused by one end of the bus losing a proper termination in a terminator resistor. The breaks can be hard to diagnose, especially in large networks.

Variants of the bus connect workstations in a physical star pattern but behave electronically as a bus. The prevalent example is AT&T's StarLAN.

A ring topology has devices connected in a series with the connection looping the last station to the first station, forming a ring of cable. All data pass through all devices. The sending device must listen for the packet it sent coming around from the other side, and not repeat it. Like a bus, any break in the cable causes the network to fail.

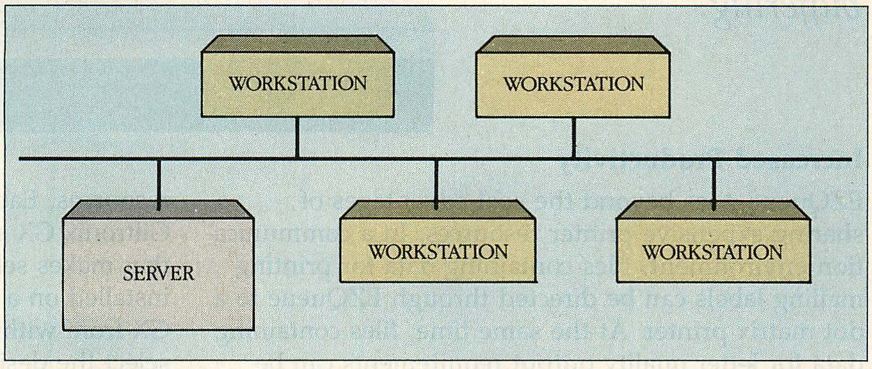
The star-wired ring (figure 4) physically connects workstations in a star ar-

FIGURE 1: *Star Topology*



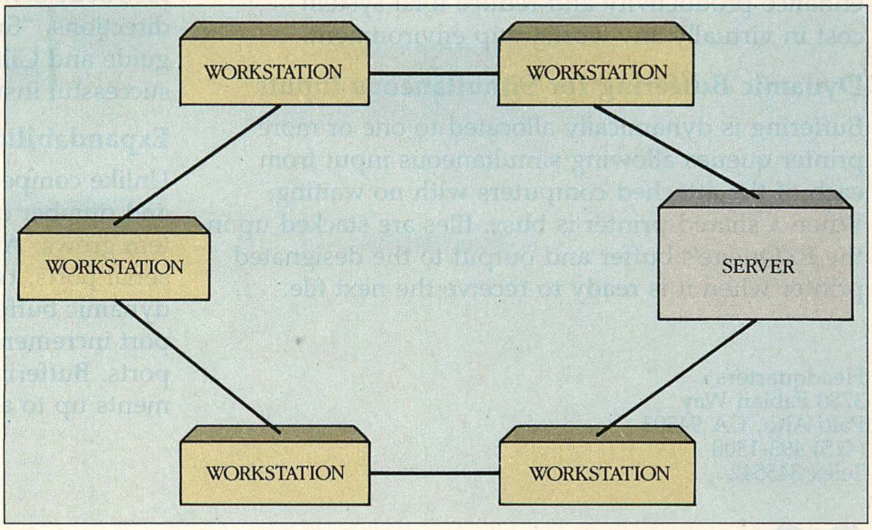
A star network uses dedicated cables to connect all stations to a central hub. The pure star places the server there, thus avoiding contention on the cables.

FIGURE 2: *Bus Topology*



A bus network threads a single main cable through all stations. Sometimes, short cable spurs are used to connect the workstations to the bus.

FIGURE 3: *Ring Topology*



Ring networks thread a main cable through all stations, similar to the bus topology except that the ends of the cable are connected to form the ring.

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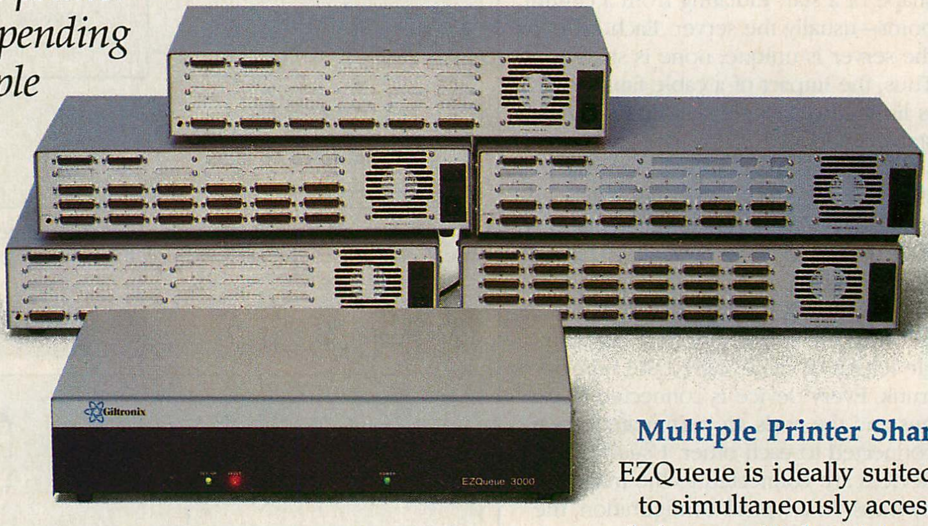

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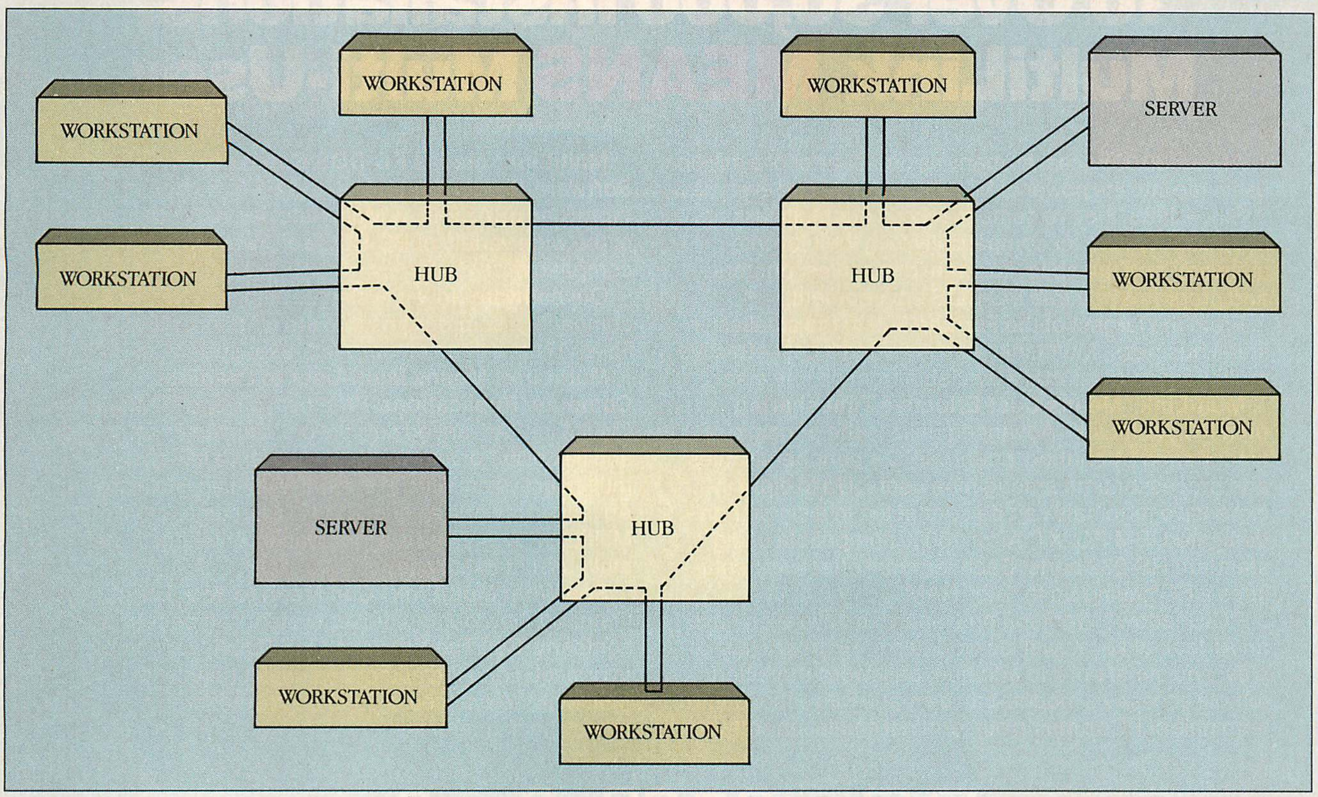
FIGURE 4: *Star-wired Ring*



IBM's 802.5 Token-Ring Network is logically a ring, but physically wired as a star. This simplifies wiring and diagnostics.

rangement to a hub. The hubs are, in turn, connected in a wire ring. All devices are logically configured in a pure ring, with the hub serving as a connection point to nearby devices. The IBM Token-Ring Network is an example of this type. Another variant, the bus-wired ring, is used by 3Com for its 802.5 network. Both networks are electrically compatible and can be mixed.

Line access method. The line access method is the type of signaling used on he line that allows multiple devices to share the same cable, communicate on it, and not interfere with another device. The IEEE defines the two methods that distinguish bus LANs: CSMA/CD and token passing. The IEEE-defined ring network, 802.5, uses token passing.

The IEEE line access methods use the same type of error checking. Error detection is typically performed by the receiver hardware using the 32-bit frame check sequence cyclic redundancy check (CRC) field. The CRC checksum is formed as a function of the address, length, and data and pad fields. CRC is used as a more powerful and less risky error detecting mechanism than normal parity checking.

Speed. Among the standardized networks, the rate at which packets are transmitted on the network varies from StarLAN's 1 million bits per second (Mbps), token ring's 4 Mbps, token bus's 1 to 10 Mbps, and Ethernet's 10 Mbps. This raw data transmission speed is only one of many factors affecting the overall performance of the network.

Cable. The type of cable connecting workstations can greatly influence installation costs. CSMA/CD networks use two types of coaxial cable (coax) and twisted pair for StarLAN. Thick coax is used for Ethernet long runs; less costly thin coax can be used for short runs. Token-passing bus networks use several types of 75-ohm coax; for the fastest implementation, CATV-like semi-rigid cable is recommended. For token-ring networks, shielded twisted pair, such as IBM Cabling System type 2, is best. Unshielded twisted pair (ordinary telephone wire or IBM type 3) can be used in environments with low electromagnetic interference.

Geographic span. The maximum distance across the total network—the distance between the farthest nodes—is the geographic span. All 802 networks can be repeated or extended. Without repeaters, 802.3 CSMA/CD networks on thin coax can span 305 meters. Thick coax extends the span to 1,000 meters. A token-bus network's span depends upon the expected performance. Token-ring cable can be up to 100 meters from the hub; the maximum span is 300-600 meters depending upon the exact arrangement of the ring.

Selective repeaters, also known as *bridges*, are another method used to expand networks. They use a store-and-forward feature to repeat only packets destined for segments attached to a particular repeater. Selective repeaters can improve the performance of multiple segmented networks because local segment packets are not forwarded.

Address size. The address size determines the number of different devices that can be connected to the network. All new CSMA/CD implementations use a 48-bit address; older implementations use 16 bits. Token buses and rings use either a 16- or 48-bit address, depending upon implementation. The 48-bit address is usually the manufacturer's code—as set by the IEEE—and serial number to provide a unique identification of all network devices.

THE CONTENTION PROTOCOL

IEEE standard 802.3 for the CSMA/CD protocol evolved from the original baseband version developed by Robert Metcalfe and David Boggs of Xerox's Palo Alto Research Center in 1976. It has experienced widespread implemen-

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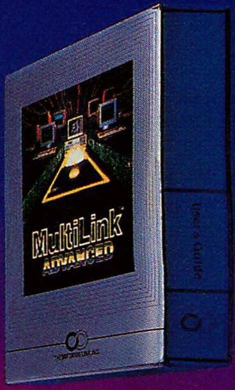

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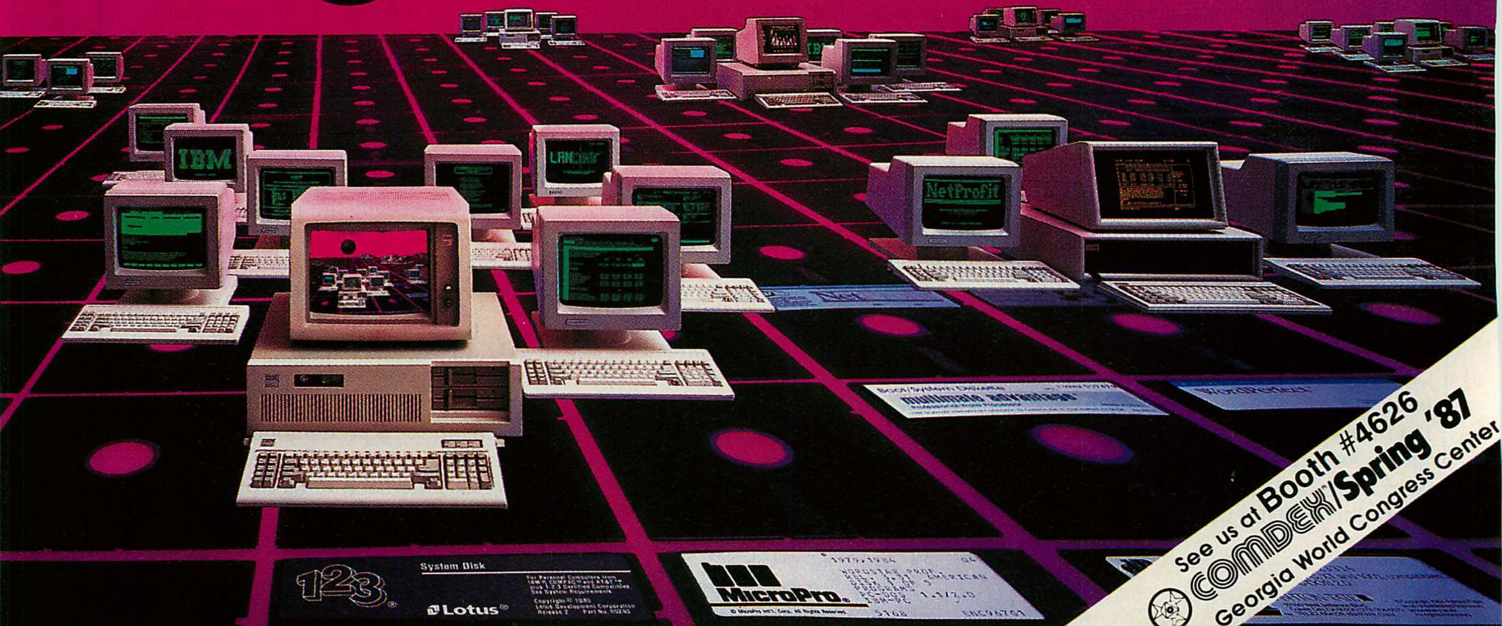


tation not only by Xerox, but also by Digital Equipment, Hewlett-Packard, Intel, and 3Com. IBM has announced an 802.3 interface for its 370-class 9370 computers. CSMA/CD differs from other protocols in that control of network access is not centralized. Instead a degree of cooperation between network devices is required to share the communications media equitably.

Conflicts arise when more than one device attempts to transmit on the single shared cable at the same time. CSMA/CD is a *contention protocol*, which assumes that occasional conflicts will occur and defines the methods for detecting and correcting these conflicts. This approach differs from token-passing networks in that each device earns the right to transmit by receiving a *token*, which is a unique string of bits that serves as a control signal. Once a device takes possession of the token, it has the exclusive use of the communications media.

CSMA/CD can be better understood by defining the three elements that comprise its name:

Carrier sense. Before a device transmits it listens to ensure the media are not being used. A voltage pulse train, or *carrier*, is transmitted on baseband systems to indicate the media are in use.

Multiple access. As soon as the media are available a device can begin transmitting. There is no need to wait for a token or other type of poll before initiating a transmission.

Collision detection. Occasionally, more than one device may attempt to transmit simultaneously. When this happens a *collision* occurs. The transmitting device monitors the communications media for high voltage levels while transmitting. A voltage level greater than one that would be expected from a single transmitting device signals a collision.

After the transmitting station detects a collision it immediately terminates the transmission of data, instead sending enough jamming noise so that all devices on the cable will sense a collision. All transmitting stations then wait a random amount of time before they attempt to retransmit. The scheduling of the retransmissions is determined by a controlled randomization process called *truncated binary exponential backoff*. After each repeated failure on a transmission attempt, a station doubles the mean value of the random delay. As the network becomes more heavily loaded, stations dynamically adjust, attempting to transmit less often.

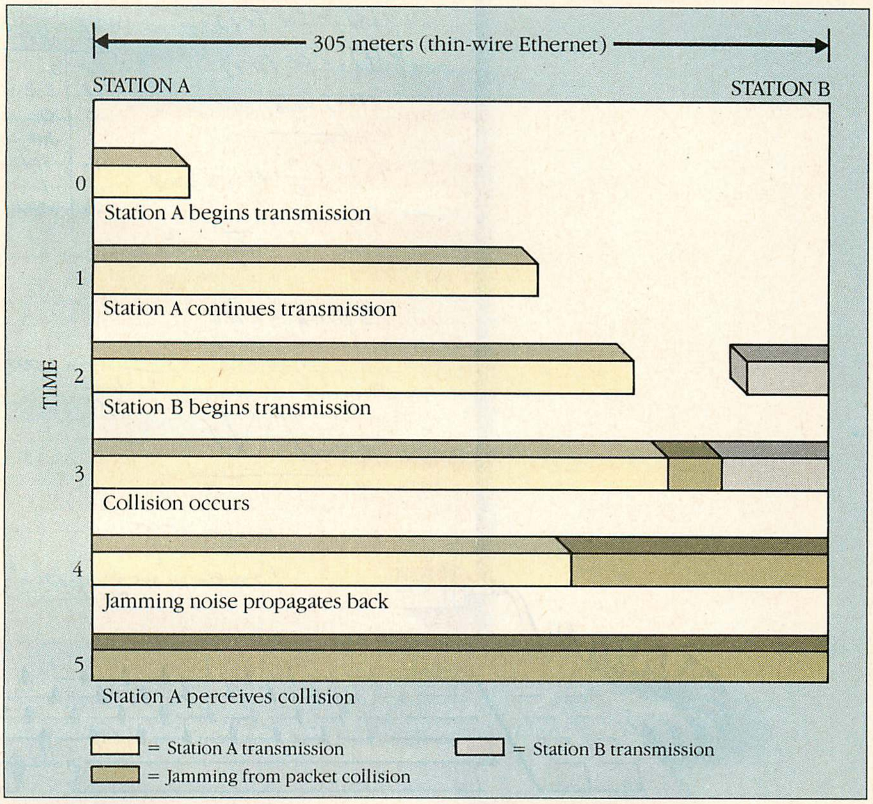
Collisions can occur only during an initial *collision window*, defined as twice the maximum network propagation delay. The size of this window is essentially the length of time it takes a transmitting station to detect a collision. Figure 5 illustrates a worst-case scenario—where stations A and B are as far apart on the network as is physically possible. A collision does not occur until the data packet from station A has propagated down the network to station B. Station A must continue to transmit at least until the collision jamming noise propagates back over the network to it. Once this worst-case collision window has passed, any transmitting station will have seized the transmission channel and will not be interrupted until the entire packet has been sent.

Data are transmitted in packets of $8n$ bits, where $46 <= n <= 1{,}500$. The minimum size of $46 * 8$ bits ensures that collisions are detected while transmission is in progress. Short messages are padded with binary zeros to the minimum length; longer data messages are broken into several packets. The data are sent using split phase encoding, a binary signaling method that combines data and clocking pulses. With this Manchester encoding technique, the first half of each data bit is at a voltage that is the inverse of the bit value, and the second half is the true value of the bit. Thus, each bit period always has one transition from a positive voltage through zero to negative, or vice versa. This transition forms a carrier that stations must listen for before beginning a transmission.

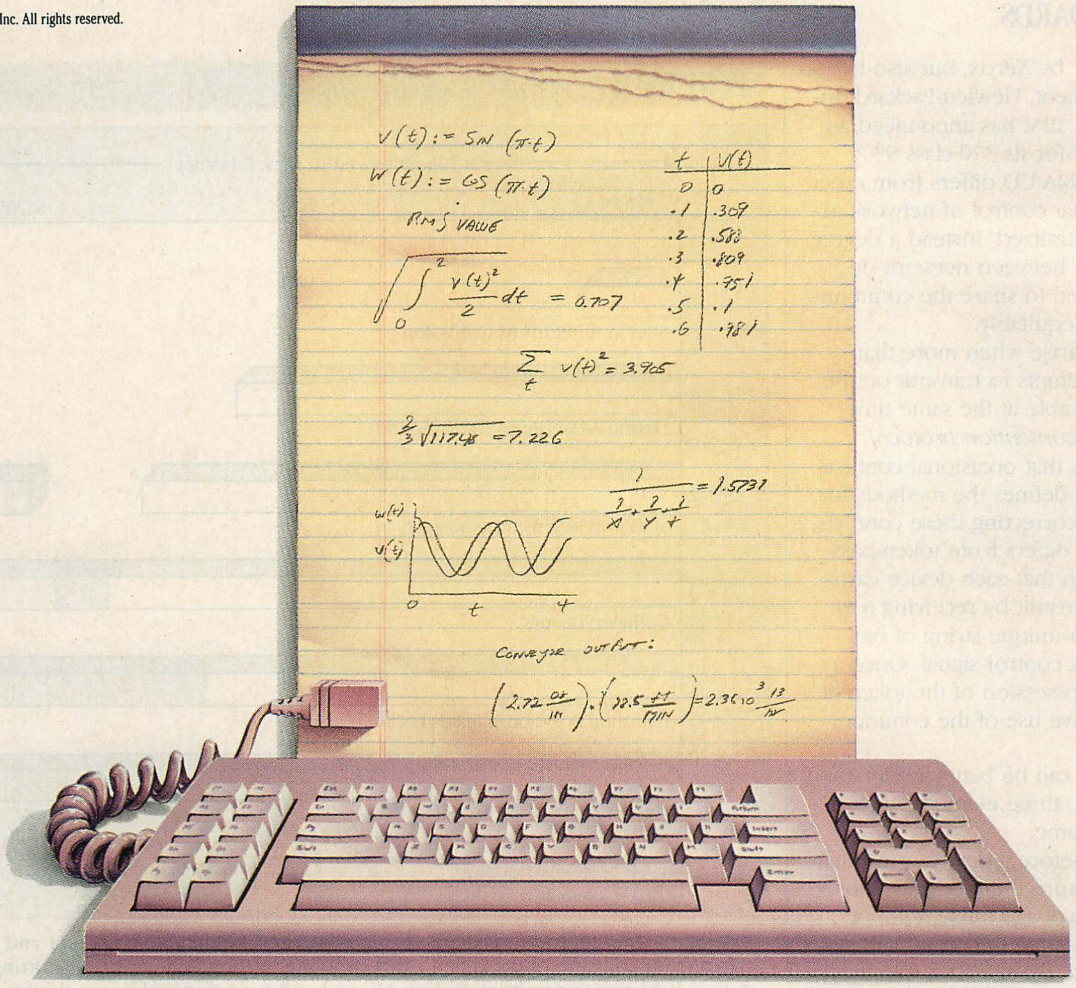
Packets comprise a synchronization preamble, address fields, data fields, and a 32-bit frame check sequence CRC field. The preamble field is 64 bits, which allows enough time for the receiving hardware to stabilize and synchronize to the incoming bit stream. This field is immediately followed by the start frame delimiter (SFD) field. Address fields are 48 bits and identify the destination and source of the packet. A destination address of all binary 1s indicates a broadcast packet, which is to be received by all stations. Each network device has a unique address.

As data are sent over the network, all stations receive each transmitted packet, assembled and validated by the MAC layer of the network interface. Completed packets then travel upward to the LLC level, where the destination address is checked. Only when a station receives a packet with its address, or

FIGURE 5: *Ethernet Packet Collision*



Sharing of the Ethernet bus depends on all stations being able to detect and recover from collision of packets. In this example, station A begins transmitting; then, station B begins transmitting before A's packet has propagated down the bus.



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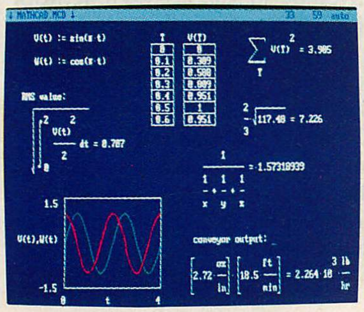

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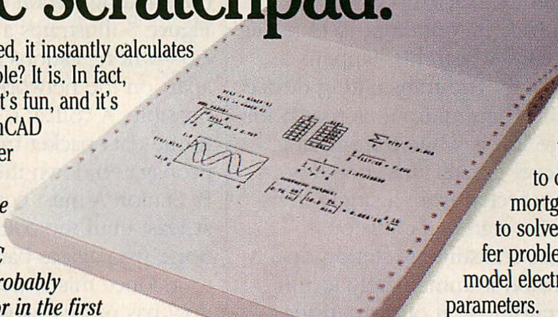

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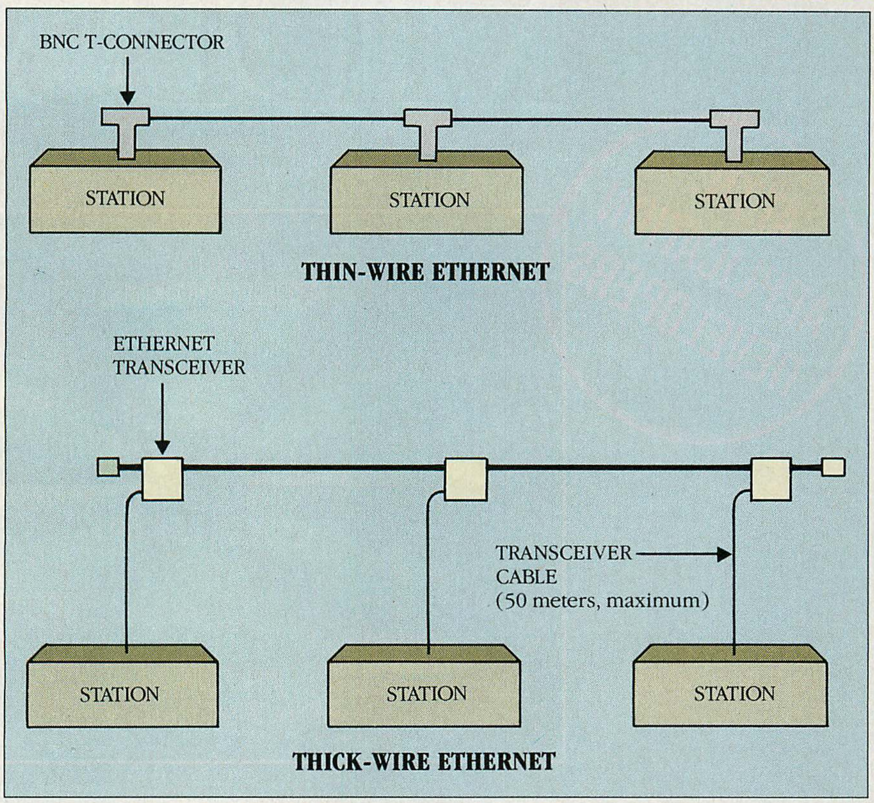
with a broadcast address, does the interface hardware pass the packet to the network station for further processing.

The data field of a packet is composed of a 16-bit length field and a maximum 12,000-bit data field. The length field counts the number of 8-bit fields (octets) that are present in the data field. If the data field size is less than 368 bits, it is padded with zeros. Full transparency is provided in the data field—that is, any arbitrary sequence of bits can be sent.

FIGURE 6: *Ethernet Configurations*



In thin-wire Ethernet, a T-connector on the network interface card attaches the station to the bus. Thick-wire configurations uses a tap and a short spur cable.

Adapted from NetWare Installation Supplement for 3Com EtherLink and EtherLink Plus

ETHERNET IMPLEMENTATIONS

An Ethernet-based LAN consists of one or more segments of coaxial cable arranged in a bus topology; the segment cable visits each network device, and only one path traverses the network. Ethernet cable segments can be as short as 1 meter or as long as 1,000 meters. Ethernet networks can be implemented using either baseband or broadband.

Ethernet baseband networks use two different types of coaxial cable: thin (RG-58, 50 ohm), for trunk segments of less than 304 meters; and thick (RG-11, 50 ohm), which can be installed in lengths of up to 500 meters. Some vendors, such as 3Com, supply transceivers able to operate on thick coax segments up to 1,000 meters in length.

Ethernet's thin wire was designed for office LANs. It can be ordered either in a variety of precut lengths with connectors installed or in bulk. Devices are attached to a thin-wire network via BNC T-connectors. A minimum distance of 1 meter is required between each station to control standing waves. Each end of the thin-wire segment must be terminated (electrically completed) by a BNC 50-ohm terminator. A maximum of 100 stations can be connected to a thin-wire segment. Figure 6 shows an example of a thin-wire Ethernet network.

The thick-wire version, sometimes referred to as *backbone Ethernet*, supports wider area networks; it can be used to tie together thin-wire networks. As in thin-wire implementations, the number of taps (device connections) and their spacing and length are limited by the need to control standing waves. Stations are connected to a thick wire via an external transceiver (figure 6). The minimum distance between transceivers is 2.5 meters; the maximum length of the cable connecting a device to a transceiver is 50 meters. A thick-wire segment can support up to 100 transceiver connections.

Thick and thin wire can work in combination in Ethernet implementations. In these combination networks the maximum segment length lies between the thick- and thin-wire maximums. The following formula calculates a maximum segment length (in meters) in a mixed media implementation:

$$\text{Max\_Segment} = \text{MIN}(T + (E/3.28), 1{,}000)$$

where T is the length of thin wire and E is the length of thick wire.

Ethernet networks can be extended with repeaters. A maximum of two repeaters is allowed in a path between any two network stations. A standard repeater has about the same delay as a 500-meter segment, because it must recover the clock for each packet and adjust gain controls. Repeaters are attached to the Ethernet wire via transceivers and can be placed on any permissible transceiver connection point. They contain logic to prevent the failure of a network segment from disabling the entire network; they do not repeat erroneous signals. Multiport repeaters, such as Digital Equipment's DEMPR unit, can connect up to eight thin-wire segments in a star topology.

Repeaters that are connected by fiber optic cable are now available from some vendors. With this cable, the maximum distance between segments can reach beyond 1,000 meters.

STARLAN IMPLEMENTATIONS

StarLAN is AT&T's twisted-pair implementation of the CSMA/CD protocol. Even though StarLAN's 1-Mbps speed is slower than Ethernet's 10 Mbps, the ease of wiring the network outweighs most performance considerations, especially in small networks.

The wiring uses a four-pair modular cord that closely resembles normal modular telephone cable. However, standard four-pair modular telephone cables cannot be used without modification, because the pin configurations on the jacks are different. Instead, AT&T DE8A-DE or compatible modular cord with AT&T 451-A connection adapters can be used if necessary.

StarLAN networks can be configured in a star topology, a daisy chain, or a combination of the two. StarLAN's daisy-chaining ability is an important advantage. Each device is linked in series to the next, with the Ethernet-equivalent T-connector integrated into the NIC. The output of one workstation card leads to an input on a second card (see figure 7). The daisy-chained installation is appropriate for a network with 10 or fewer stations and with a maximum distance between the two ends of the cable measuring less than 122 meters.

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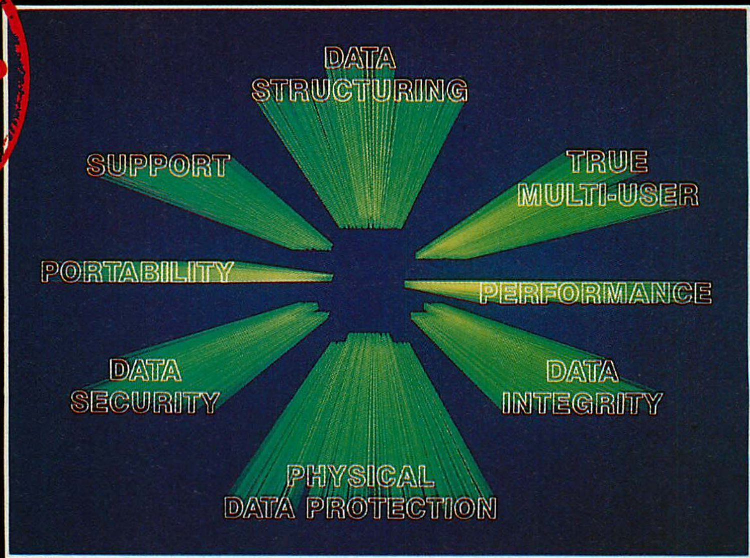

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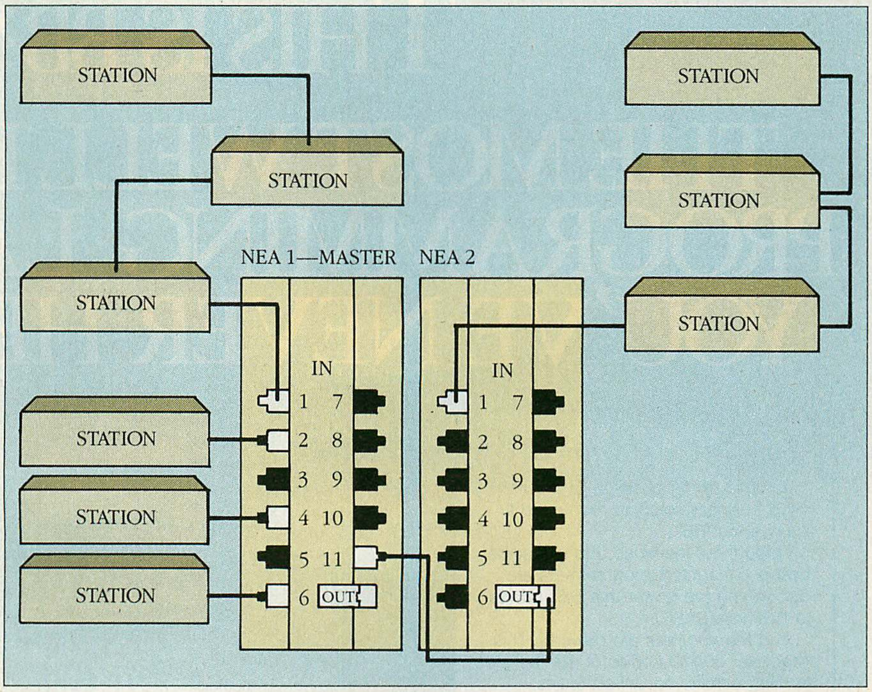
A network that exceeds 122 meters must incorporate a star topology in which each device is cabled back to a central point, called the network extension unit (NEU). As many as 11 stations can be connected to a single NEU, each using up to 245 meters of cable. A network with more than 11 stations requires multiple NEUs, one of which must be configured as a master device with all others connected to it with 10 feet or less of cable. Secondary NEUs cannot be used to extend the geographic span of a StarLAN network.

StarLAN is flexible enough to allow both a daisy chain and star topology in the same network. As figure 7 shows, daisy chains composed of 2 to 10 stations can be cabled back to a single NEU port. The maximum distance allowed from a particular daisy chain to the NEU is as follows (in meters):

STATIONS	DISTANCE
2–5	245
6	225
7	190
8	170
9	140
10	125

The distance can be extended with a network interface module connecting the StarLAN network to AT&T's information systems network (ISN) data switch. ISN supports a variety of connections at distances of up to a few thousand meters (depending on wiring), but the necessary protocol conversion is not supported by all network software, such as Novell's NetWare.

FIGURE 7: *StarLAN Configurations*



In small StarLAN networks, stations can be daisy-chained; larger networks must use a star coupler to extend capacity. Both methods can be used in a single network.

Adapted from NetWare Installation Supplement for AT&T StarLAN

TOKEN-PASSING BUSES

Installing a network in a factory requires a great deal of flexibility in topology—in cable lengths and the ability to use trees and stars, with repeaters. The network must be extremely reliable and have an upper bound on response time. The token-passing bus helps meet these objectives. The manufacturing automation protocol (MAP), developed by General Motors and the Society of Manufacturing Engineers, implements a token-passing bus; its basic concepts also are used in ARCnet networks.

The IEEE 802.4 standard defines a token bus that can be implemented in baseband, broadband, and hybrid applications. The bus behaves similarly to the token ring in that its algorithm passes the token in a sequential manner from station to station.

A token bus behaves logically as a ring network, as shown in figure 8. After a station has completed transmitting any data frames, the station sends a token MAC frame to its successor. It listens for evidence that the successor has heard the frame and is active. If the token sender does not hear a valid frame, it listens for up to four time slots and then retransmits. If the successor still does not transmit a valid token frame, it assumes the successor failed. The sender then transmits a *who follows* frame that queries all stations, asking who follows the specified address of the failing successor. This allows the sender to establish a new successor and continue passing the token.

Response windows allow new stations to enter the logical ring. Special *solicit successor* frames specify a range of open station addresses, to which an entering station responds if its address is within the range. The soliciting station must establish a new successor if one responds. Like the token-ring protocol, priority bits can be used to bypass stations with low priority frames.

Three media and transmission methods are included in standard 802.4. The 1-Mbps version uses an omnidirectional bus and 75-ohm coaxial cable, such as RG-6, RG-11, and semirigid (CATV). Drop cables are 25- to 50-ohm stubs, less than 350 millimeters long. A long, unbranched trunk cable with very short stubs is recommended. Active regenerative repeaters can be used for branching and extension of the system. Signaling is by Manchester encoding.

A 5- and 10-Mbps baseband version also uses an omnidirectional bus and 75-ohm cable, with very short drops. Semirigid cable with RG-6 drops is recommended. Active repeaters are used for branching the bus and extensions of the cable. Signaling is by frequency shift keying (FSK) with direct encoding of data and nondata symbols at particular frequency shifts.

The broadband version uses CATV-like semirigid trunk cable and flexible drops. Standard CATV amplifiers are used, with head-end regenerative repeaters that provide the clock signal. Speeds of 1, 5, and 10 Mbps are supported in broadband channels of 1.5, 6, and 12 MHz, respectively. Signaling is by amplitude modulation of the radio frequency signal, with three levels: zero, nondata, and one. The nondata level is used to ensure synchronization.

ARCNET

Although Datapoint's ARCnet is related to the 802.4 token-passing bus standard, it predates that standard and thus does not strictly conform. Unlike the IEEE standards, ARCnet is a result of informal cooperation by many manufacturers, including Davong, Nestar, Standard Microsystems, Tiara, and Waterloo. The ARCnet standard is followed so closely by these companies that a network can be set up with different cards, all communicating transparently.

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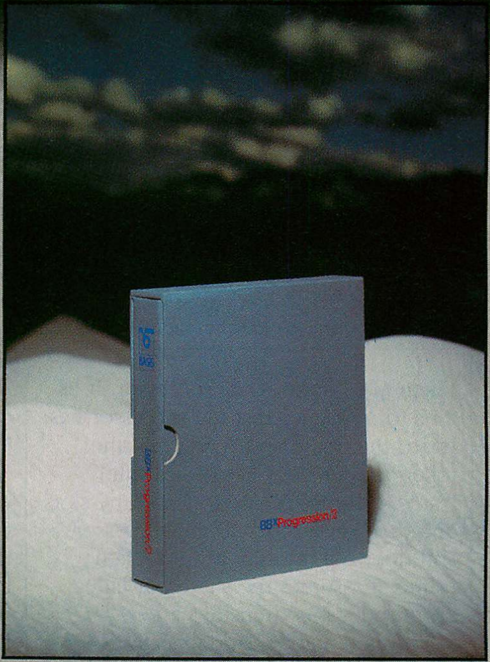

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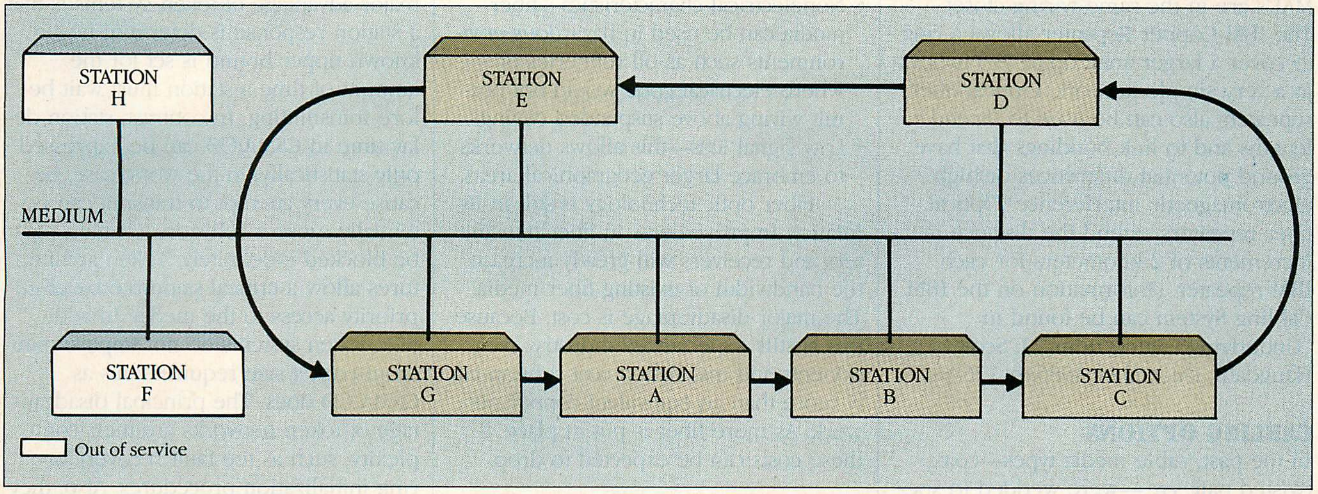
FIGURE 8: *Token-passing Bus*



A token bus behaves logically like a token ring. An assigned sequence determines the order in which stations access the bus.

A distributed star architecture, similar to StarLAN, is used to implement the bus, which runs at 2.5 Mbps. ARCnet is limited by being able to send only single packets of 508 bytes. Novell NetWare sends 560-byte read and write packets to its file server, so an ARCnet system must send two packets, with the second requiring an additional token cycle. The positive acknowledgement of the token system keeps an upper bound on response time, however.

ARCnet stars are centered with active and passive hubs. A passive hub has four connectors for up to four workstations in a simple network, or it connects three to an active hub. An active hub conditions, boosts, and relays the signal to stations, passive hubs, or other active hubs. It has eight connectors.

An ARCnet network must not exceed 6,000 meters. The maximum distance between an active hub and a network station or another active hub is 600 meters. The maximum distance between an active hub and a passive hub is 30 meters, as is the maximum distance between a passive hub and a network station. Passive hubs cannot be directly connected, and no loops are allowed. The cable is RG-62 93-ohm coax, with BNC connectors.

TOKEN-RING ACCESS

After several experimental implementations of the token-ring access method, Prime Computer and Apollo began selling such networks in the early 1980s. Meanwhile, IBM issued several statements of direction and published its wiring plan with token ring in mind, then announced a version to network PCs as the first implementation. IBM's network has now been extended to link an IBM 3725 mainframe communications controller to a PC, to allow the PC to function as a terminal or gateway.

The existence of a nonproprietary standard, combined with IBM's support, has made IEEE's 802.5 a very popular protocol. Many vendors offer products that are compatible with 802.5, including General Instrument, Proteon, 3Com, and Ungermann-Bass. Diagnostic tools, such as Network General's Sniffer protocol analyzer, are also available. (For more detailed information on the 802.5 token-ring network, see "The Token-Ring Solution," J. Scott Haugdahl, January 1987, p. 50.)

A token ring consists of a set of workstations connected by a cable in which data are transmitted sequentially from one station to the next; the receiving station is responsible for repeating and regenerating the signal to the next station in the ring. The station whose address matches the destination address field in the packet copies the information as it passes and processes it according to the MAC functions of layer 2 in 802.5. The address station also passes the information to the next station on the ring; the station that transmitted the packet finally removes it from the ring.

A station is authorized to transmit when it detects a token. When a station captures the token, it can modify it to make a frame, consisting of the start-of-frame sequence, control and status fields, address fields, information fields, the frame check sequence, and the end-of-frame sequence. After this new frame is created, the sending station initiates a new token, which allows other stations around the ring to access it. A token-holding timer controls the maximum amount a time a station can use the medium, either transmitting a new frame or not, before passing the token.

The 802.5 standard includes a system of priorities, determined by the type of message, such as synchronous, asynchronous, and immediate (network recovery). The present IBM token-ring implementation for PCs does not support priorities, however.

The protocol used for initializing a token ring and recovering from hard errors defines a complex, five-state, finite state heuristic machine. The 802.5 standard includes a protocol for failure domain identification that notifies all stations farther around the ring of a failure. This may not allow the network to heal itself, but an error message could help pinpoint the failure.

IBM's TOKEN-RING

In its Token-Ring Network, IBM allows two types of cable: a shielded twisted pair (types 1, 2, and 9) and unshielded telephone-style wire (type 3). The IBM type 1 cable allows more reliable communications and has longer distance allowances than type 3.

A maximum of 260 devices can be connected on a ring, including 33 IBM Multistation Access Units (MAU). All cables (or lobes) from the distribution panel containing the MAU to the workstations must be less than 100 meters, with some exceptions if the overall network is small. For a permanent installation, IBM recommends a rack in each wire closet into which cables to all possible stations terminate on IBM cabling system connectors. Short lengths of type-1 cable are used to patch the rack connectors to the MAU.

IBM provides charts to compute the allowable lengths of various seg-

ments in its Token-Ring Network. The longest segments are possible when all MAUs are in the same wiring closet. The IBM Copper Repeater allows a ring to cover a larger area, up to 775 meters in a very simple network. Optical fiber repeaters also can be used to extend lengths and to link buildings that have ground potential differences or high electromagnetic interference. Optical fiber repeaters extend the distance in increments of 2 kilometers for each IBM repeater. (Information on the IBM Cabling System can be found in "Underlying Connections," J. Scott Haugdahl, December 1986, p. 126.)

CABLING OPTIONS

In the past, cable media types—coax, twisted pair, etc.—were wedded to specific network protocols. For example, 802.3 systems were available on only two varieties of coax. This will not be true in the long run. The industry is evolving to media-independent implementations of the major IEEE network standards. 3Com recently announced support of unshielded twisted-pair wiring for its 10-Mbps Ethernet system, and IBM supports three types of media on its Token-Ring Network.

Normal telephone grade (24-gauge, unshielded) twisted-pair wiring is becoming the de facto standard for small departmental LANs. This cable is inexpensive and easy to work with. In many cases extra pairs of existing telephone wire can be used to implement a small LAN with minimal cost.

For larger networks—involving multiple floors in the same building, for example—either coax or higher gauge shielded cable is preferred. Networks that span larger geographical areas—such as between buildings—most often use fiber optic media.

In general, the trend is toward fiber optic media. A consensus is developing for a standard 62.5-micron core; 125-micron-cladding fiber was originally designed for moderate-distance links between telephone switching offices. Because it transmits light, fiber cable can provide communications speeds 10 to 100 times that of copper media.

Other advantages to fiber media include the following:

- Small size and weight—a single fiber can be used to replace a 300-pair telephone trunk cable.
- Immunity from electromagnetic interference—especially important in environments such as hospitals, manufacturing sites, and television studios where copper media can easily pick up electromagnetic noise.
- Security—the fiber cable must be broken to be tapped.
- Nonelectrical characteristics—fiber media can be used in hazardous environments such as oil refineries or where electrical code would not permit wiring above suspended ceilings.
- Low signal loss—this allows networks to embrace larger geographical areas.

Fiber optic technology is still in its infancy. Improvements in fiber transmitters and receivers will greatly increase the bandwidth of existing fiber media. The major disadvantage is cost. Because this is still a specialized industry, components and installation cost substantially more than an equivalent copper network. As more fiber is put in place, these costs can be expected to drop.

Followers of these IEEE LAN hardware standards are quite unlikely to find themselves in possession of orphaned technology.

Recently, an ANSI committee (X3T.9) published a standard for a variant of the 802.5 token ring that operates on high-speed fiber media. The Fiber Distributed Data Interface (FDDI) defines a token-ring network that communicates through fiber at 100 Mbps. Up to 500 nodes can be placed on the network, which can be as large as 100 kilometers in circumference. FDDI's most innovative feature is fault-tolerance: the ring can recover from a cable break or station crash without intervention. This reliability is accomplished with a second counter-rotating ring. When two stations detect a break between them, they redirect traffic to the secondary ring, reestablishing the connection.

STANDARDS FOR THE FUTURE

Each of these LAN hardware standards has characteristics that make it a commendable design choice for a particular environment. The CSMA/CD protocol is relatively simple, works well at low to medium network utilizations, and is widely implemented by a variety of manufacturers on many types of media. Most LANs that are not time critical can be successfully implemented on CSMA/CD systems. The lower installation costs of StarLAN networks make it an ideal choice for small networks.

Under heavy loads, however, token networks provide better performance. A major advantage of token systems is that a station response is deterministic—a known upper bound is set for the amount of time a station must wait before transmitting. In contrast, station delay time in CSMA/CD can be expressed only statistically; in the worst case, because every attempt to transmit can potentially cause a collision, a station may be blocked indefinitely. Token architectures allow a critical station to be given priority access to the media. In addition, token systems do not impose minimum packet size requirements as CSMA/CD does. The principal disadvantage of token networks are their complexity, such as the fault recovery or ring initialization procedures. Also, they exhibit a fair amount of overhead, especially under lightly loaded conditions.

Regardless of the choice of LAN technology, the benefits of opting for one of the standards presented here are overriding. Support from multiple vendors creates competition, which leads to product improvements and better value per dollar. Followers of these standards are also unlikely to find themselves in possession of orphaned technology; the same cannot be said for networks proprietary to one vendor.

The widespread support of hardware standards leads LAN software vendors to provide operating systems that run on standard networks. For example, Novell's NetWare supports ARCnet and all of the 802 standards; 3Com's 3Plus supports Ethernet and IBM's Token-Ring. In contrast, IBM's PC LAN operates only on the Token-Ring and IBM's proprietary networks. By selecting a LAN operating system that supports multiple standards, it is possible to use identical software across multiple LANs, yet still be able to choose the most appropriate LAN hardware.

As evidenced by the vendor implementations discussed here, there is considerable room for innovation within the bounds of these standards; the use of the 802.5 standard as the foundation for FDDI is one example. Although standards can sometimes be faulted for locking in the technology of the past, the IEEE standards are flexible enough to serve into the future.

Art Krumrey is director of user's services, information systems, at Loyola University, where he has installed 10 networks. John Kolman is director of computer networks and support, also at Loyola University. He has installed a multisegment Ethernet network throughout the Loyola Medical Center.

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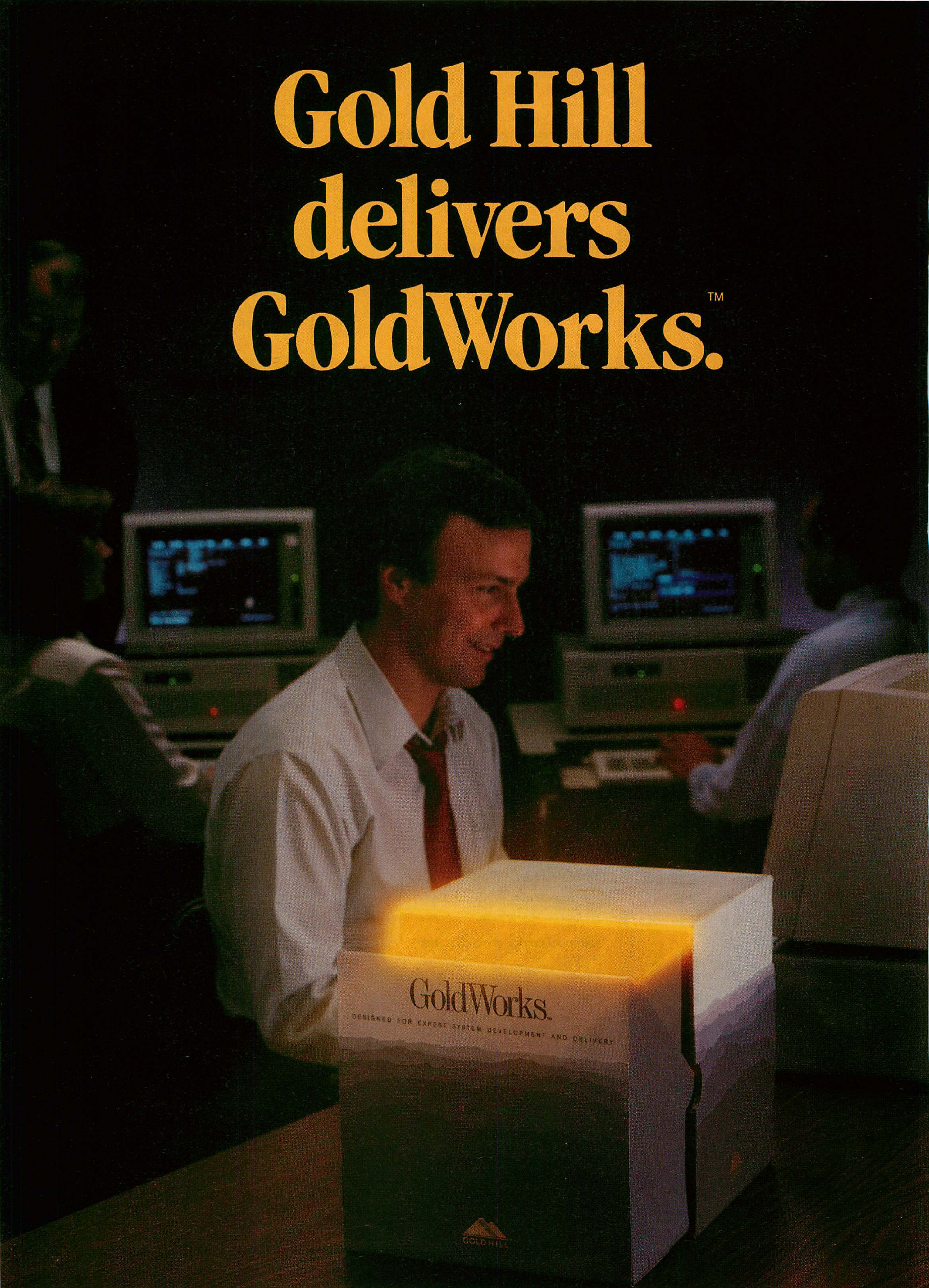

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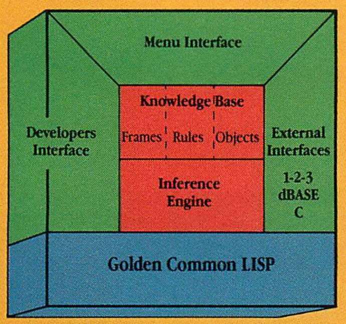

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GOLD HILL™

COMPATIBILITY 286 PERFORMANCE

OUT FROM THE SHADOW OF IBM:

Premium/286

By teaming zero-wait-state memory and a 10-MHz 80286 processor, AST Research has produced an AT compatible that outshines most of its rivals.

STEVEN ARMBRUST and TED FORGERON

AST Research, a company that manufactures almost every kind of PC add-in card imaginable, apparently saw an advantage to selling its own computer to house all those cards. The result is the Premium/286, an AT compatible with a 10-MHz 80286 processor and zero-wait-state memory (see photo 1). Although positioned primarily as a desktop publishing machine with an available laser printer and scanner, the Premium/286 is a general-purpose computer with performance figures that nearly elevate it into the new class of 80386-based machines.

While the Premium/286's system board contains many custom chips that would allow it to use one of the small-sized system units that are popular these days, the chassis is a full-sized unit that measures 19 by 16½ by 6½ inches. Like the IBM PC/AT, this large footprint allows room for two storage bays for holding peripheral devices.

Several practical features make the Premium/286 a joy to work with. For example, the operating panel, conveniently located on the left-front panel of the system unit, contains the lights indicating power-on and processor speed, a reset button, and the keylock switch, which is used to lock the keyboard electronically, rather than to lock the cover in place (see photo 2).

Three processor speed settings (10, 8, and 6 MHz) are available. The lights on the front panel plainly indicate the current speed at all times. Pressing Ctrl-Alt-uparrow switches to the next higher speed, and Ctrl-Alt-down-arrow switches to the next lower speed.

Normally the system starts in 10-MHz mode, but the SETUP program (invoked via AST's ASTUTE utility) can change the default speed so that certain programs, such as games and other copy-protected software, can be invoked at system start-up at lower speeds.

The Premium/286's reset button is an idea that should be incorporated into more computers. It performs the

PHOTOGRAPH • MARC DAVID COHEN


AST
RESET

PHOTO 1: *Premium/286 Styling*

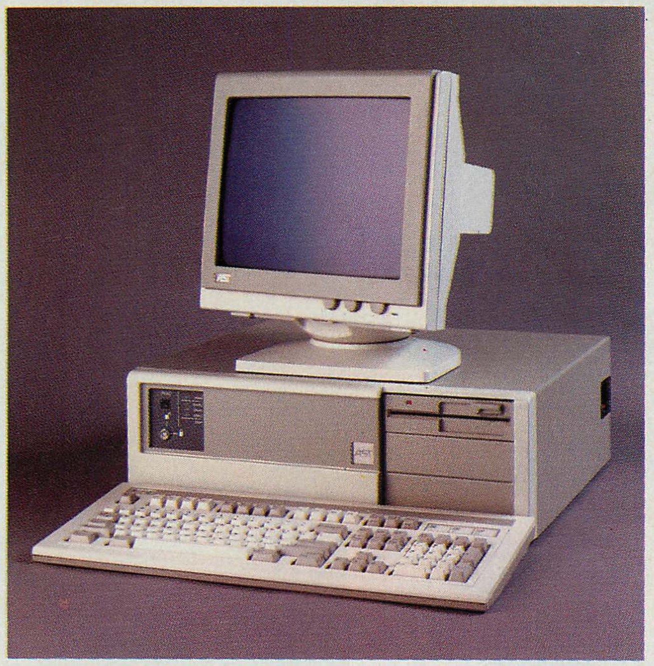


PHOTO 2: *Operating Panel*

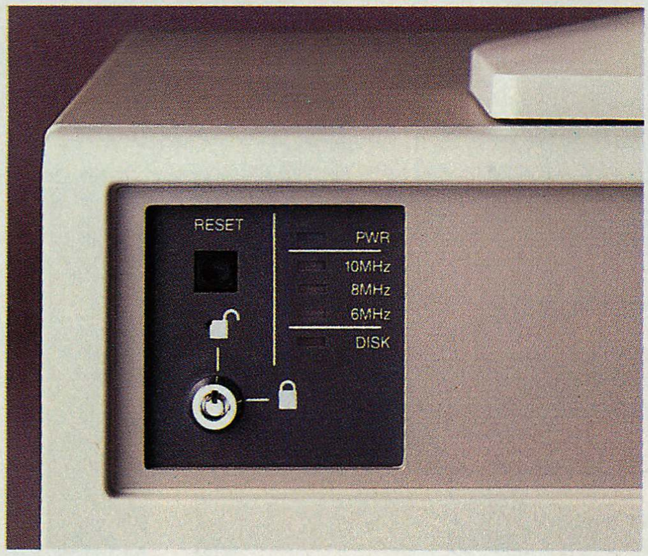


Photo 1: The Premium/286 has attractive styling in a case similar in size to an IBM AT. It measures 19 by 16½ by 6½ inches; the AT's dimensions are 21¼ by 16½ by 6¼ inches.

Photo 2: The reset button performs the same function as turning the machine off and on again. One of the three processor speed indicators is lit to note the current CPU speed.

Photo 3: The enhanced keyboard of the Premium/286 (bottom) matches the IBM enhanced keyboard, but like most compatibles, it does not have the distinctive IBM feel.

Photo 4: Slots 5 and 6 are designated the FASTslots. They are equipped with an extra connector at the front of the system board to accommodate the FASTRAM cards.

Photo 5: An AST FASTRAM card includes an extra edge connector to enable the RAM to be accessed directly from the 80286 processor's local memory bus, with zero wait states.

PHOTO 3: *Keyboard Comparison*

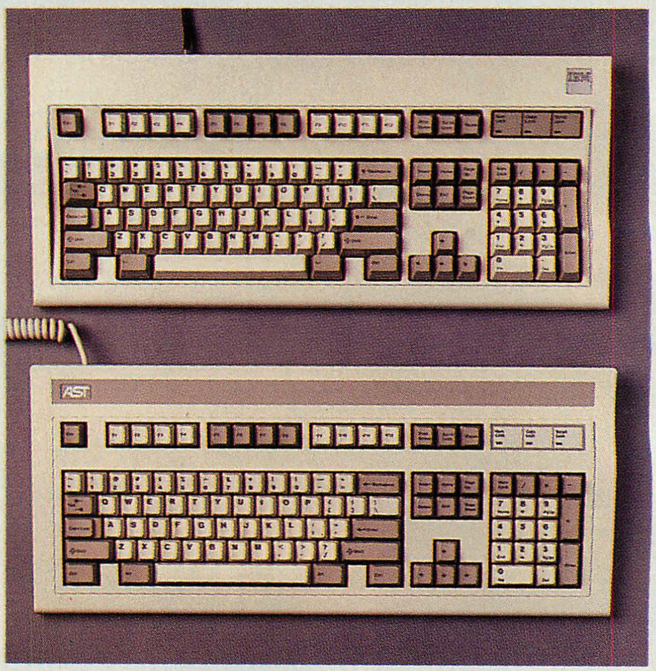


PHOTO 4: *Inside the System Unit*

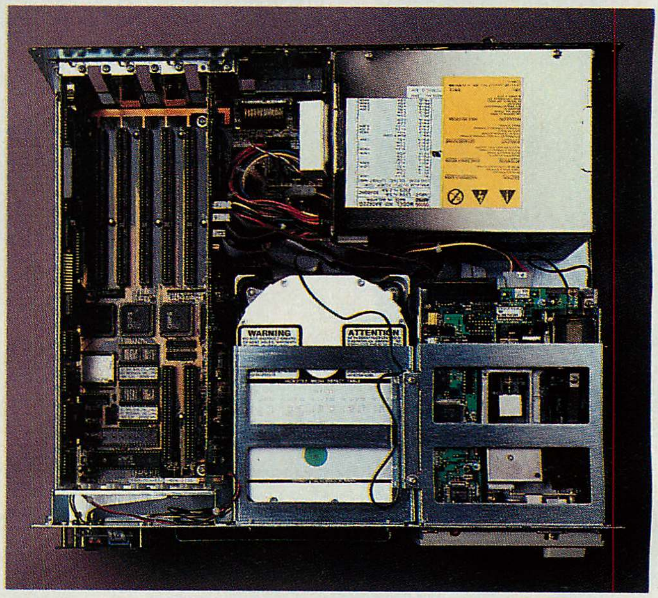
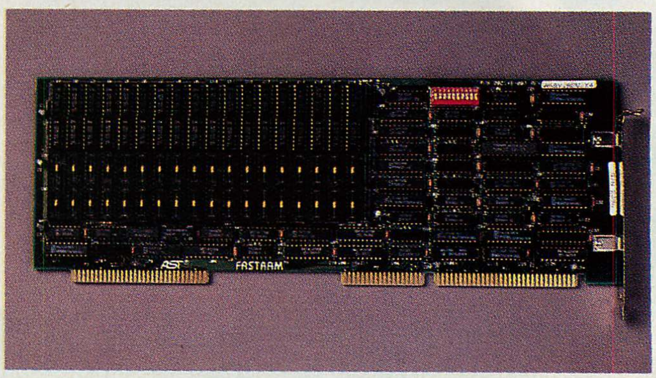


PHOTO 5: *FASTRAM Board*



same function as turning off the computer and turning it back on, but without inflicting the system or the hard disk with the trauma of suddenly losing and regaining power.

As another helpful touch, AST provides preprinted adhesive labels to identify the board in each slot. This permits clear labeling of serial and parallel ports as COM1 or LPT1, for example.

The machine tested in this article contained 1MB of AST's FASTRAM zero-wait-state memory, a 44MB hard disk, a 1.2MB diskette drive, the AST-3G graphics card (an EGA-compatible card with 256KB of memory that emulates the Hercules Graphics Card), and a 13-inch monochrome monitor. A Mouse Systems serial mouse was included.

The AST monochrome monitor is easy to read, although its foreground color is white, rather than the green or amber found in most monochrome monitors. Its contrast, brightness, and on/off knobs are all placed on the front of the display where they can be accessed easily. The AST-3G graphics card, which provides EGA-quality graphics capabilities, worked with all of the tested software. (This board was reviewed in "The EGA Spectrum, Part 1," John T. Cockerham, October 1986, p. 80.)

The keyboard is a 101-key model patterned after IBM's enhanced keyboard. Photo 3 compares the two keyboards. Like almost all keyboards except for the IBM models, the AST keyboard has a mushy feel with very little tactile feedback. Audio feedback is adequate, but Ctrl-Alt- + (the plus sign on the numeric keypad) also can be used to set the volume level of the audible click that is generated by the system each time a key is pressed.

The system board is equipped with a serial port and a parallel port as part of the standard configuration. The parallel port uses the standard IBM 25-pin female D-shell connector. However, instead of using a 9-pin serial connector like the one found in the AT, the Premium/286 uses a 25-pin male connector like those in most PCs and XTs.

Jumpers on the system board can switch the serial port between COM1 and COM2 or disable the port, and they can switch the parallel port between LPT1 and LPT2 or disable the port. The parallel and serial ports are located at the rear of the system board, just to the left of the keyboard connector, as shown in photo 4. The port connectors extend out of the rear panel.

The power supply is rated at 200 watts and appears to be compatible with the AT power supply. The on/off switch is on the right side of the power unit. The fan provides amazingly good air flow, but it makes this power supply one of the noisiest units to be found.

FAST SLOTS FOR FAST CARDS

The Premium/286 has seven expansion slots: one 8-bit slot and six 16-bit slots. Three of the Premium/286's slots are usually occupied, leaving four available for user options. The 8-bit slot (slot 1) contains the video adapter; slot 7 houses the combination diskette/hard-disk controller; and a zero-wait-state FASTRAM card is installed in slot 6 (there must be at least one, because the system board contains no RAM).

The AST computer is able to access memory at zero wait states because it provides two special slots (5 and 6) in order to accommodate the AST FASTRAM cards (see photo 5). The two 16-bit FASTslots are about the same size as the PC's 8-bit connectors, but unlike the other slots, they are equipped with an extra connector located at the front of the system board. The FASTRAM cards are designed to plug into these slots using the FASTslot connector. When this connection is made, the FASTslot connector takes precedence over the expansion bus and, therefore, enables the Premium/286 to access memory at zero wait states, even when the 80286 is running at 10 MHz.

In essence, the FASTslot connector is simply an extension of the 80286's local memory bus. In the case of the Premium/286, it is the local memory bus, because the system board contains no memory. By connecting the 80286 directly to the memory, the memory accesses do not require extra time for the signals to pass through a bus controller chip and out onto the expansion bus. Therefore, the 80286 can access memory on the FASTRAM cards in two 10-MHz CPU cycles, or zero wait states.

The signals used by the FASTslots are diagrammed in figure 1. The FASTRAM cards contain the decode and control logic to transform CPU signals into the signals necessary to access the memory on the card. Additional signals enable cards plugged into ordinary AT slots to access FASTRAM memory, for example, via direct memory access (DMA). To maintain compatibility, DMA occurs at the speed of the AT bus, rather than at the full 10-MHz zero-wait-state speed.

The FASTslots also contain Request, Grant, and Release lines. These are included so that coprocessor cards also can be plugged into the bus. AST has not yet developed any such cards.

In the minimum configuration, the Premium/286 comes with one FASTRAM card containing 512KB of RAM. An additional 1.5MB can be added in 512KB increments, so with its two FASTslots the

PREMIUM/286 VITAL STATISTICS

Model 80: $1,995
512KB memory
Parallel printer interface
Serial interface
Combination diskette/hard-disk controller
1.2MB diskette drive
Realtime clock
(does not include monitor or video adapter)

Model 90: $2,495
All features of the first model plus:
1MB memory (instead of 512KB)
AST-3G video adapter

Model 120: $2,995
All features of the previous model except with a 20MB hard disk.

Model 140: $3,495
All features of the previous model except with a 40MB hard disk.

Model 170: $3,995
All the features of the previous model except with a 70MB hard disk.

Memory capacity on system board
None. Memory is supplied via the FASTslot memory boards.

Display adapters
AST-3G+ (EGA and Hercules compatible) is available.

Monitors
Premium/Monochrome Display: $195
Premium/Enhanced Color: $695

Expansion slots
FASTslots: 2 (with 16-bit connectors)
16-bit: 4
8-bit: 1

Available slots
FASTslots: 1
16-bit: 3
8-bit: 0

Other extras available
40MB tape backup: $750
360KB diskette drive: $155
FASTslot memory cards: 512KB, $695; 1MB, $895; 2MB, $1,495

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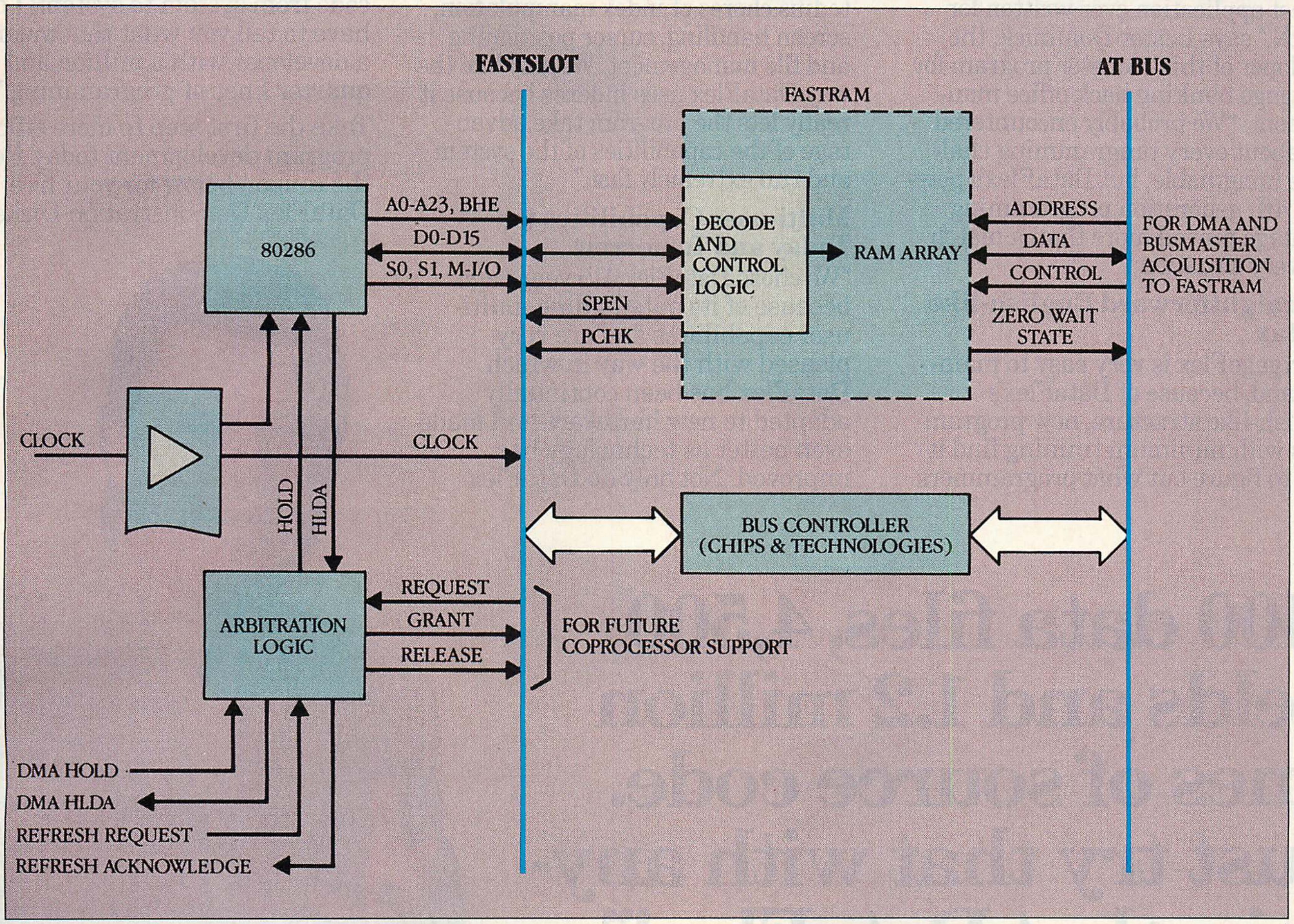
FIGURE 1: *Block Diagram Showing FASTslots.*



By extending the processor's local memory bus, the FASTslots eliminate the overhead induced by the bus controller.

Premium/286 can contain as much as 4MB of zero-wait-state memory. The FASTRAM card requires 256KB RAM chips with an access time of 100 nanoseconds. Currently, AST has qualified only Fujitsu MB81256 and Micron MT1259-10 chips for use in the FASTRAM cards.

The FASTslots are not limited to accepting only the FASTRAM cards. When ordinary 16-bit memory cards are plugged into these special slots, then the 80286 accesses the memory via the expansion bus at the same speed as the AT. The wait states that are associated with different processor speeds and slot types are as follows:

SLOT TYPE	6 MHz	8 MHz	10 MHz
8-bit	1	1	2
16-bit	1	1	2
FASTslot	0	0	0

The FASTRAM cards can be set up for three different kinds of memory. The first 640KB of the first card is devoted to conventional memory. The remainder of FASTRAM memory can be set up as extended memory (with addresses starting at 1MB) or expanded memory, adhering to the AST/Quadram/Ashton-Tate Enhanced Expanded Memory Specification (AQA EEMS), which is a superset of the Lotus/Intel/Microsoft Expanded Memory Specification (LIM EMS).

When the Premium/286 is used to run DOS, AST recommends that all FASTRAM above 640KB be set up as expanded memory. This allows AST's expanded memory manager (REMM.SYS) to make the memory available to applications that can access expanded memory directly, and it lets AST's utilities FASTDISK and SUPERSPL use the memory for RAM disks and print spoolers.

AST also provides a memory manager called REX.SYS that can be used in addition to REMM.SYS; it lets expanded memory emulate extended memory. When installed, REX.SYS intercepts the BIOS calls that perform extended memory functions and substitutes equivalent operations using expanded memory. Users can set up any combination of extended and expanded memory utilities without opening up the system unit and physically reconfiguring the memory. On the other hand, the FASTRAM cards have switches to set up extended memory directly, so that other operating systems, such as XENIX, can use the memory as extended memory.

Another bonus feature of the Premium/286 is its enhanced BIOS interrupt handling that is present in the Phoenix Technologies, Ltd.'s BIOS supplied in the machine. Phoenix offers two interrupt-handling configurations. In the standard configuration, when an interrupt occurs and no interrupt handler is set up for the specified interrupt level, an IRET instruction is executed and processing continues. With enhanced interrupt handling, such interrupts cause the following message to appear on the screen:

Unexpected SW interrupt <num> at <address>.
Type (R)eboot, other keys to continue

Similar messages are displayed for hardware and nonmaskable interrupts.

Most computers include the Phoenix BIOS without the enhanced interrupt handling feature, because that configuration is most like IBM's. However,

Case History #47582

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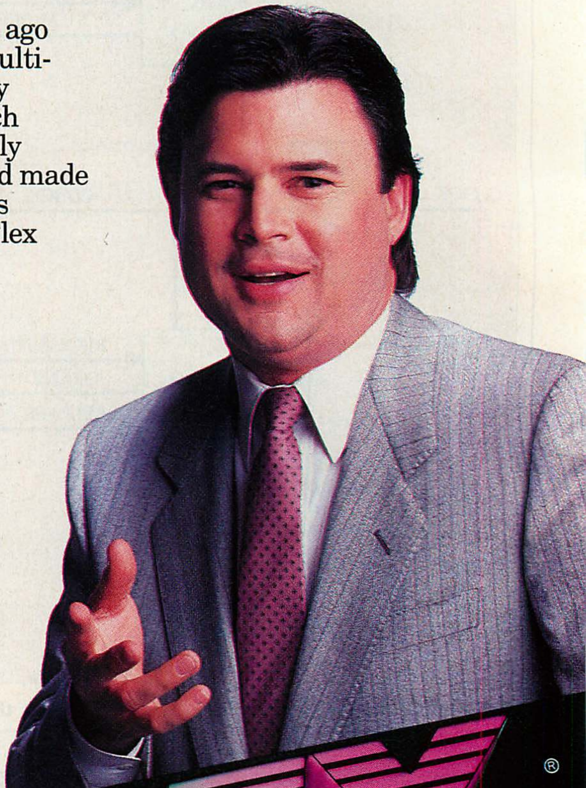

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the enhanced interrupt handling support in the Premium/286 gives programmers important extra information to simplify debugging runaway programs.

EASE OF INSTALLATION

Installation is a fairly simple process with the Premium/286. The cover of the system unit is fastened with five screws on the rear panel. The screws, which can be removed with a flat-blade screwdriver or one-quarter-inch nut driver, are accessible and easy to recognize. However, the screws in the tested unit did not seem to fit properly and were cross-threaded, as if they had been forced. This prevented the cover from being secured tightly. Also, the screws were a different type than the ones used to fasten the slot covers (which were Phillips-head screws), so at least two screwdrivers are required to work inside the system unit.

Installing diskette drives into the Premium/286 is very easy, while hard disks involve a little more effort. The left drive bay, which has no external access, is reserved for hard disks. The Premium/286's 44MB full-height Micropolis hard disk filled the left bay on the tested unit. To install their own hard drives, users must remove the screws that fasten the drive bay enclosure to the front panel, lift out the enclosure, screw the drive into it, and then replace and refasten the enclosure. This procedure requires considerable dexterity.

The AST documentation does not mention the drive types that are supported by the Premium/286. However, the SETUP program lists the characteristics of the 35 drive types that are supported by version 3.02 of the Phoenix BIOS. Drive types 1 through 15 match the IBM drive types.

The drive bay on the right side has room for three half-height drives (or one half-height and one full-height drive). The 1.2MB drive was mounted as the topmost drive in the enclosure in the evaluation unit. The drives can be screwed directly to the enclosure without requiring additional slide rails or mounting hardware.

The Premium/286 provides two unused power connectors for installing additional drives. Adding a second diskette drive requires only the drive itself, because the cable is already present in the system unit. However, only one of the cables necessary for adding a second hard disk is included; the 30-pin controller cable has connectors for two hard disks. The other necessary cable, a 20-pin data cable, is not provided, although the disk controller has a connection for one. AST includes no documentation for adding drives or for setting options on the controller board to support additional drives.

Except for the FASTRAM cards, inserting and removing expansion cards is easy. The FASTRAM cards, because of the extra connector on their front-panel side, are more difficult to install.

Other areas of the system are quite accessible. The 80286 and 80287 sockets are at the left front of the system board and can be reached without removing the power supply or disk drives. The 80287 socket can be a little hard to recognize, because if the unit is configured without the 80287, a header that reduces radio frequency interference is plugged into the socket. The switch that selects the primary video adapter also is conveniently located on top of the display panel (near the processor speed lights, reset button, and keylock switch) inside the system unit.

STANDARD SOFTWARE

As is the case with many of the IBM-compatible computers, MS-DOS 3.1 and GW-BASIC 3.1 are included with the Premium/286. In addition, AST includes Utility Software and Diagnostics diskettes with the system. The Utility Software diskette contains REMM.SYS (the

The FASTDISK program is a flexible driver that combines conventional, expanded, and extended memory into a single RAM disk.

expanded memory manager), REX.SYS (the extended memory emulator), FASTDISK.SYS (a RAM-disk driver), SUPERSPL.COM (a print spooler), and an installation utility to set up the system with these programs and drivers. The FASTDISK program is an especially flexible driver that combines conventional, expanded, and extended memory into a single RAM disk.

The Diagnostics diskette contains the set-up and diagnostics programs. DIAG.EXE tests the AST-3G display adapter; EMUL.COM allows the adapter to emulate a Hercules Graphics Card; and PREVIEW.COM sets the number of graphics pages to be used in the Hercules mode. Other files on the Diagnostics diskette include SETUP.COM (which stores system set-up information into battery-maintained memory), HDFORMAT.EXE (which performs a low-level format of the hard disk), and ASTUTE (AST's diagnostic test executive). HDFORMAT.EXE and ASTUTE are advanced utilities that are not normally included as standard software with personal computers.

From ASTUTE, users can run the set-up program, do a low-level format of the hard disk, and park the disk heads. In addition, ASTUTE automatically senses the type of hardware in the system and displays the results on the screen. Included in this information is the hard-disk drive type, amount and type of memory, number and types of serial and parallel ports, display mode, and keyboard type.

The ASTUTE diagnostics consist of a comprehensive set of programs that allows users to explore the dark corners of their systems for possible errors. However, version 1.02 of the diagnostics, which was distributed with the tested unit, seems to have problems of its own, reporting errors that do not really exist. For example, when run on the tested unit, ASTUTE reported the following problems:

Bad Memory Board Probable Cause Of Failure
00:00:19 → Map Control Register Failure
Replace System Board
01:08:09 → Processor Speed Failure
Serial Port is Defective
03:06:01 → Defective Adapter Logic

Despite these error messages, the unit itself seemed healthy; no problems ever surfaced when testing with applications software or add-in hardware. For example, the "Map Control Register Failure" message occurred only when the Intel Above Board was in the system and might have been caused by the program assuming that Above Board is an EEMS device, which it is not.

Part of the problem is that no documentation is supplied with ASTUTE. The manuals provide no information about individual tests, nor do they mention loopback connectors or other devices that might be required to make the tests run correctly. When AST was contacted, it admitted that early versions of ASTUTE have bugs. It sent the latest version (1.1B), which corrects many of the problems. This version does not report processor speed failures, and it documents on the screen that some of the serial port tests require loopback connectors to run correctly. However, even with this new version, the test still reports a "Map Control Register Fail-

ure" when the Intel Above Board is installed in the system.

UP TO THE TESTS

As with every other computer tested in this series, the Premium/286 underwent a full range of tests. First, a series of commonly used software and hardware products were installed to check compatibility. Then the *PC Tech Journal* compatibility and performance metrics were run and the results were compared with the 8-MHz IBM AT. (For details on these metrics, refer to the article "Out from the Shadow of IBM...," Steven Armbrust, Ted Forgeron, and Paul Pierce, August 1986, p. 53 and "Updating the Evaluation Suite," Ted Forgeron, Paul Pierce, and Steven Armbrust, March 1987, p. 71.)

The hardware products tested with the Premium/286 were an 80287 numeric coprocessor, an Intel Above Board with 4MB of memory, Microsoft serial and bus mice, a Hayes Smartmodem 1200B, an IBM Color Graphics Adapter, and IBM Personal Computer Color Display. The AST-3G card and the Mouse Systems serial mouse provided with the system were also tested.

In general, all of the products tested worked in the Premium/286. However, when both the AST FASTRAM and the Intel Above Board were configured for expanded memory, neither expanded memory manager (EMM) could recognize the other company's memory card when configured for expanded memory. Only one EMM can be active in any computer at one time. However, the Intel EMM was much more graceful about the situation. Intel's EMM.SYS recognized the memory on the Intel board and simply ignored the FASTRAM expanded memory. On the other hand, AST's REMM.SYS tried to set up the Above Board memory as EEMS memory and caused the entire system to crash, requiring a power down to correct the problem. This conflict should seldom cause a problem, however, because most Premium/286 users will want to use the zero-wait-state FASTRAM memory whenever possible.

The software products tested included Microsoft Windows 1.03 and Word 3.1 to test graphics capabilities and the mice. Borland's SuperKey 1.15, SideKick 1.56A, and Turbo Lightning 1.101A tested memory-resident programs. Living Videotext's Ready! 1.00C, Intel's QUIKMEM2 RAM disk, and AST's FASTDISK RAM disk were used to test expanded memory. IBM's VDISK checked the computer's ability to switch in and out of protected mode. FastBack, from Fifth Generation Systems Inc., was used to test direct memory access. Finally, the IBM SETUP program and Advanced Diagnostics were used to give the computer a general checkup.

All of these programs worked without error. In addition, the Premium/286 passed all of the IBM Advanced Diagnostics tests, which few computers are able to do. Even FastBack, which sometimes requires the computer to be set to a slower speed, worked at the 10-MHz speed on the Premium/286.

The expanded memory programs (Ready! and QUIKMEM2) were tested by running them out of the EEMS memory on the FASTRAM card, and both ran without problems. After disabling the FASTRAM's expanded memory, the programs also ran well using expanded memory in the Intel Above Board.

The *PC Tech Journal* compatibility and performance tests used for this series on compatibles consist of five programs: ATBIOS checks the BIOS and BIOS data areas; ATKEY checks for keyboard compatibility; ATPERF measures CPU and numeric coprocessor clock rates, as well as memory access times; ATFLOAT measures floating-point operations with the numeric coprocessor; ATDISK measures hard-disk performance. Table 1 compares the results of these tests with those of the 8-MHz AT.

The Premium/286 passed all of the tests on the IBM Advanced Diagnostics diskette, which few computers are able to do.

The ATBIOS program showed that the Premium/286 has a BIOS manufactured by Phoenix Technology Ltd. with a version number of 3.02. It uses the BIOS data area in the same way that the AT's BIOS uses the area.

Keyboard compatibility was verified with ATKEY. When the original IBM AT keyboard was plugged into the AST machine, it also worked without error.

ATPERF revealed how the combination of a 10-MHz CPU and zero-wait-state memory affects performance. The 80286 was indeed measured at 10 MHz, and the 80287 numeric coprocessor ran at 8 MHz. Using the zero-wait-state memory on the FASTRAM card, the RAM and EMM read and write times were almost 1.9 times faster than the same operations on an 8-MHz AT.

For these values to be truly appreciated, they must be compared to other high-performance computers. In fact, these values are better than those recorded by the ALR Access 386 (which contains a 16-MHz 80386 and interleaved memory), better than the values recorded by the PC's Limited 286[12] and Compaq Portable III (both of which contain 12-MHz 80286s and one-wait-state memory), and close to the values recorded by the Compaq Deskpro 386.

This puts the Premium/286 in the upper echelon of 286-based AT-class machines when considering RAM access times. Of course, when measuring areas in which the Premium/286's zero-wait-state memory does not have an effect, such as ROM reads and video writes, the machines with faster processors have better times. For a comparison of these compatibles, see "Poised for Tomorrow" (Access 386), Michael Abrash and Dan Illowsky, April 1987, p. 104; "PC's Limited 286[12]," Steven Armbrust and Ted Forgeron, February 1987, p. 94; "Portable III," Jim Shields, May 1987, p. 76; and "The New Standard" (Deskpro 386), Steven Armbrust and Ted Forgeron, March 1987, p. 48.

The ATFLOAT test showed that the Premium/286 can process floating-point operations 1.4 times as fast as an 8-MHz AT. With its 10-MHz CPU and 8-MHz numeric coprocessor, these values are consistent with expectations.

ATDISK revealed good news about the hard-disk drive in the Premium/286. The 44MB Micropolis drive in the tested unit performed better all around than the AT's hard disk. The average seek time (29.5 milliseconds) is comparable with that of the hard disk in the Deskpro 386. The drive is formatted with an interleave of 2 and works well at that interleave, giving it a higher transfer rate than the AT's hard disk.

MISSING DOCUMENTATION

The documentation accompanying the Premium/286 consists of the *User's Reference* (which corresponds to IBM's *Guide to Operations*), *MS-DOS Reference*, *GW-BASIC Reference*, and *Utilities Software* manual (documenting the REMM and REX drivers, the FASTDISK RAM-disk program, and the SUPERSPL print spooler), as well as reference manuals for the AST-3G graphics card and Mouse Systems mouse. This set of documentation has a professional appearance and uses figures and tables liberally. However, the MS-DOS manual is printed with light gray characters on

white paper, giving it a washed-out look that makes reading more than a page or two at a time difficult.

In general, the AST manuals provide the basic information that the average user needs to run the Premium/286, but there are some deficiencies. The biggest of these is the lack of detailed technical information. No hardware or software technical reference manuals are available from AST. Furthermore, the AST diagnostics programs are not documented. This lack of technical material frequently is one of the items that separates the top-tier suppliers (such as IBM, Compaq, and Hewlett-Packard) from all the others.

AST provides a one-year limited warranty for the Premium/286. The warranty covers parts and labor but is limited to the original purchaser. During that time, users can return the machine to their dealers for repair or replacement. AST provides a technical-support telephone line to handle problems not covered in the documentation.

AN OUTSTANDING PERFORMER

The Premium/286 is one of the most pleasing 80286-based personal computers in the marketplace. It is extremely compatible with the AT, having successfully run every product tested on it. The well-designed unit is sturdy and offers convenient extras such as a reset button, which software developers especially will appreciate. Only the AST diagnostics programs showed any problems with the machine, and none of the problems noted by the diagnostics surfaced in any other part of the testing.

What sets the Premium/286 apart from many other AT compatibles is performance. Its 80286 runs at only 10 MHz, as compared to 12 MHz for some of its competitors. However, when teamed with zero-wait-state memory and a fast hard disk, the Premium/286 outshines almost all of its rivals. It is proof that a well-designed 80286 machine can offer performance rivaling an 80386 machine.

AST Research
2121 Alton Avenue
Irvine, California 92714-4992
714/863-1333
Premium/286
CIRCLE 352 ON READER SERVICE CARD

Steven Armbrust is a freelance technical writer, and Ted Forgeron works as a program manager for Intel Corporation. Together, they are the authors of the Programmer's Reference Manual for IBM Personal Computers *(Dow-Jones Irwin, 1986).*

TABLE 1: *Compatibility and Performance Tests*

	8-MHz AT, 30MB DISK[a]	PREMIUM/286, 44MB DISK (at 10 MHz)
ATBIOS		
ROM BIOS date	11/15/85	10/23/86
ATPERF		
Average RAM instruction fetch (ms)		
BYTE	.250	.20 (125)[b]
WORD	.403	.21 (190)
Average RAM read time (ms)		
BYTE	.401	.21 (187)
WORD	.401	.21 (187)
Average RAM write time (μs)		
BYTE	.401	.21 (189)
WORD	.401	.21 (189)
Average ROM read time (μs)		
BYTE	.401	.32 (125)
WORD	.401	.32 (125)
Average CGA video write time (μs)		
BYTE	1.208	1.21 (100)
WORD	2.415	2.41 (100)
Average EMM read time (μs)		
BYTE	.402	.21 (188)[c]
WORD	.402	.21 (188)[c]
CPU clock rate (MHz)	8.0	10.0 (125)
Numeric coprocessor clock rate (MHz)	5.3	7.9 (149)
Refresh overhead (%)	7.1	6.0
RAM read wait states	1	0
RAM write wait states	1	0
ROM read wait states	1	1
Video write wait states (CGA)	8	10
EMM read wait states	1	0[c]
EMM write wait states	1	0[c]
ATFLOAT		
Performance as percentage relative to AT	100	104
ATDISK		
Sectors/track	17	17
Heads	5	5
Cylinders	731	1,022
Total space (million bytes)	31.81	44.48
Track-track seek time (ms)	6.0	4.9
Average seek time (ms)	37.1	29.5
Effective transfer rate (KB/sec)	170.1	255.0
DOS file I/O (sec)	7.3	7.6
Interleave	3	2

[a]The figures for the IBM AT are the average results from several machines, whereas the results from the AST Premium/286 are taken only from the review sample model.
[b]Figures shown in parentheses represent the relative performance expressed as a percentage compared to PC Tech Journal's *baseline machine, the 8-MHz, 30MB AT.*
[c]EMM measurements were taken using the Premium/286's FASTRAM memory configured as expanded memory using the REMM.SYS driver.

The combination of 10-MHz CPU performance and the zero-wait-state memory provided by FASTRAM cards results in RAM and EMM read and write times on the Premium/286 that are almost 1.9 times faster than they are on an 8-MHz AT.

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Brief has text search abilities rivaling "grep", with wildcards for matching, indifference to intervening characters, acceptance of character ranges.

If you use Lattice, C86™, or Wizard, and have 320k, you can compile your C program without ever leaving Brief. It finds the lines with errors, and marches you through the text for repairs.

Parts of Brief were written with its own Lisp-like macro language which has structure, 32-character variable names, conditional execution, loops, and you can actually read it! Nothing like the hieroglyphs we've seen elsewhere. Bulletin board and public domain disks with macros. "Simply the best text editor you can buy", Dvorak *Infoworld*. (Needs 192k.)

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U0590	$195	**Call**

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Windows for C™ is a library of over 80 functions to add the pizazz and practicality of window partitioning to your application. Unlimited windows, each defined in a C structure for easy reference throughout your program, can be made either to pop up or permanently overwrite the screen. Routines will scroll and highlight lists with arrow keys, will read and scroll ASCII files vertically and horizontally in windows, and even write to memory-loaded files off the screen.

Logical treatment of video attributes permits unchanged programs to run on color or monochrome. Colors of windows are set individually. All functions are in separate modules. Only those used are linked. Only buffers holding on-screen or temporarily obscured windows occupy RAM; others released dynamically.

Windows for Data comprises all of Windows for C but takes in data through the windows as well. At the high level a single function lets you specify prompt string, field length, data type, screen location, picture, target variable, then sets lesser functions scurrying to get and process a user's input. There are utilities to get system date and time, mess with strings, create your own masks for fields.

Field options can require or prevent entry, beeping on invalid or overflow keystrikes, and attachment of field-specific help messages and functions you want called to display messages or validate entries. And you decide which keys will clear a field, jump to the next or prior, quit, etc. Clear manual to boot.

Specify Compiler:	List:	PC Brand:
T0100 Windows for C	$195	$149
T01500 Windows for Data	$295	$259

MICROSOFT C 4.0 *A Great C Battle Rages and You're Winning*

It bundles a source debugger and a "make", and sports a "huge" memory model permitting single data objects larger than 64k, but what's really impressive about Microsoft C are the benchmarks reported in Dr. Dobb's. Microsoft runs away from a field of 17 winning 11 of 27 benchmarks.

The CodeView™ debugger uses windows to show everything on one screen: source alongside disassembled object, variables, stack and registers. Drop down windows obviate learning of commands. "A source-level debugger that puts the rest to shame" said Dobb's.

Microsoft C has five memory models for code and data, plus non-library support for another thirteen, and boasts alternate math packages for speed versus accuracy, with or without 8087/80287 chips.

Both linker and library manager are part of the package, as is the "make", which knows how to rebuild any size project by compiling only elements which have changed.

It is reportedly used by Lotus, Ashton-Tate and, fittingly, Microsoft itself to develop Windows. Dobb's calls it "the best MS-DOS C development environment value today [for] virtually any kind of program conceivable." 320k suggested.

Ask for:	List:	PC Brand:
G0500	$450	$295

HALO GRAPHICS SYSTEM *Multi-Board Graphics Library*

The premier graphics library that got the ball rolling for PC-based graphics and has grown so omnipotent that it supports over 25 graphics boards — including IBM's EGA and Nr. 9 Revolution's hi-res series — and has a multitude of mouse and printer drivers. All that in each box. Separate C versions for Lattice, M'soft, Aztec, C186. What does Multi-Halo do? A down to the last pixel graphics library plus functions to reset drivers so distributed program can run on anything. Wonderful value for single license. Costly royalties though for redistribution. Specify: S0315 & Language. List: $300. We: **$219.** With Dr. Halo II, a free-standing "paint": List: $440, Us: **$299.**

C-TREE & R-TREE *B-Tree File Manager Now Has Report Generator*

c-tree: Seasoned to perfection, c-tree™ is the only major b-tree file manager with network support in the standard low-cost version. It allows multiple users to access an index file simultaneously even during updating. Record-locking routines are provided for DOS 3.x, UNIX and XENIX.

C-tree even comes in C source code, yet there are no royalties. Source sticks to K&R, so C-tree is portable. Tests in many environments prove it.

C-tree permits any number of keys for a data file—alpha, numeric, even floating point. It handles files with varied record lengths and keeps multiple keys in one index file. Has both high level ISAM routines to handle details with minimum coding, and decomposed step-by-step functions you can access directly. In short, you get the works.

r-tree: thousands of c-tree users (and you) now have a suddenly expanded ability to produce ad hoc reports from files maintained by c-tree (v. 4.1 and up). Just link a file description to the r-tree library, and all you need is an ordinary text editor to write any number of report scripts with no further C coding. Reports can access data in several files, select on criteria, join the findings into new logical records, sort them, calculate new fields and columns, tabulate by any number of control breaks. The script files show a visual representation of the report image for easy creation and maintenance of even elaborate layouts. r-tree™ comes in source, boasts the same portability as c-tree, and fits any compiler.

	List:	PC Brand:
c-tree: F0660	$395	$329
r-tree: F0665	$295	$245
Combined:	$650	$541

dBC *Lattice Library Maintains dBASE Compatible Files With the Power and Speed of C*

dBC™ links C to dBASE. It creates and maintains files and their indexes which exactly replicate dBASE file design. So dBASE can read and update them. And the reverse. dBC can use any files created by dBASE. Now C and dBASE can operate on the same data bases interchangeably.

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dBC's functions parallel all dBASE's file handling commands, many decomposed to give closer control. Each backed by demo source files on disk.

Use dBC for custom work for clients, or on its own. It's a complete ISAM file manager for C whether or not dBASE will be used in tandem, supports all four memory models, and can have sixteen index and data files open. Big discount to buyers of both dBASE II and III versions. Specify Lattice, Microsoft 3.x, or DeSmet.

Versions:		List:	PC Brand:
L00II	For dBASE II	$250	$195
LCCII	With Source	$500	$390
L0III	For dBASE III	$250	$195
LCIII	With Source	$500	$390

POLYTRON VERSION CONTROL *Source Code Control for Any Language*

PVCS allows programmers, project managers, librarians and system administrators to control the proliferation of revisions and versions of source code in software systems. Independent programmers, the leading software publishers and LAN companies, and hundreds of Fortune 1000 companies rely on PVCS to store and retrieve multiple revisions of text. It maintains a complete history of revisions as an "audit trail", generates status reports, and uses intelligent "difference detection" to minimize disk space for each new version.

On Corporate and Network PVCS simultaneous changes to a module are merged into a single new version. If changes conflict, the user is notified. The "Logfiles" used to track changes are interchangeable between any PVCS product.

Corporate PVCS is for multiple programmers. It includes "branching" to maintain code when programs evolve on multiple paths. Personal PVCS offers most of the power and flexibility of corporate PVCS, but excludes multiple programmer features. Network PVCS is the Corporate version for LANs. File locking and security levels can be tailored to each project.

PolyMake Still using a prehistoric Make? Step up to PolyMake, the most popular and powerful Make utility. Most flexible macros of any Make. Now integrated with PVCS and PolyLibrarian for faster performance and precise configuration management.

Ask for:	List	PC Brand:
Personal PVCS	$149	$109
Corporate PVCS	$395	$309
Network PVCS	Call	Call
PolyMake	$149	$109

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Telex: 667962 (SOFT COMM NYK)

TODAY's TOP QUALITY AIDS TO PROGRAMMING PRODUCTIVITY

SUPER SOURCE

Two great debugging and documentation tools that support C, Modula, Pascal, BASIC, and dBASE:

Source Print

Author Alan Simpson writes "the best overall debugging technique is to... draw lines to connect all the IFs and DO WHILEs etc. with their ENDIFs and ENDDOs. Use a pen or pencil to..." Well thanks, Alan, but we'll let Source Print do it for us. It draws vertical lines to connect all such beginnings and endings in a vivid display of your program's organization. And it can print programs with page numbers, headings, line numbers, indent automatically, throw in a table of contents and a cross-reference index. About Source Print *PC Magazine* said, "Occasionally a utility comes along that makes a programmer's life much easier." List: **$75**, Ours: **$60**.

..and Tree Diagrammer

Tree Diagrammer prints an organization chart of your program's structure showing the hierarchy of function, procedure, and subroutine calls. Shows at a glance what routines call each other for clearer debugging. Every shop should have this important documentation tool. List: **$55**, Ours: **$45**.

GREENLEAF

Functions

C source, assembler source, and binary libraries of 225 functions for many compilers. Stresses tight functional groupings to minimize loading code your application may never use. Manual's 250 pages help select functions, as do demos, bulletin board. Has DOS extensions, powerful string pointer manipulations, screen tools even to the pixel level, graphics primitives, keyboard, register and memory status, F-key assignment, time/date, peek, poke, plenty more. Specify compiler. List: **$185**, Here: **$139**.

Communications

Communicate from within your own C programs! Over 120 functions and demo programs in C and assembler source to set up interrupt-driven asynch communications for up to 16 channels. Up to 9600 baud, ASCII or binary, any parity or word length, 8250 UARTs, Xon/Xoff and Xmodem, WideTrack receive. Specify compiler. List: **$185**, Us: **$139**.

BASTOC OPTIMIZES!

Translates BASIC Into C

For a trifling price, BASTOC™ moves truckloads of BASIC over to C. It's a translator which takes in Microsoft Extended BASIC and emits pure K&R C for Microsoft or Lattice. Structures even convoluted BASIC code. Optimized to dramatically reduce execution time. Dynamic string allocation ends BASIC's catatonic garbage collection. Huge worksaver. List: **$495**, PC Brand: **$399**.

RYAN-McFARLAND

Killer FORTRAN OPTIMIZES!

Complete implementation of FORTRAN-77, the first PC FORTRAN certified by the GSA at the highest level. Why? It's a mainframe compiler moved to PCs. Your programs can wander between all sizes of machines. Programs up to 640k (bigger with overlays), arrays over 64k, long list of VS, VAX and FORTRAN-66 extensions. Has debugger, overlay linker. R-M has written FORTRAN compilers for IBM, DEC, etc. for 20 years. No greater expert. List: **$595**, Us: **CALL**.

PANEL PLUS *Library Source Code Gives It Complete Portability*

NEW! NO ROYALTIES!

There are no end of tools for screen design and data entry, but none quite like Panel Plus. Design a screen under program control, use Panel's utility to "run" and test it field by field, then pass it to Panel's code generator which delivers C source code. Options style the code to your compiler's liking, and you can of course do what you like to the source afterward. The code calls Panel Plus's function library, but now *the library comes in source*, so everything produced is highly portable. Not like other screen managers delivered as object libraries and which leave *you* to write the detailed code.

Panel Plus will operate in graphics mode via interfaces to graphics products it supports and can utilize the EGA's 43-line screen. Low-level I/O functions adapt it to various keyboards, screens, operating systems.

Panel's newest incarnation has every imaginable feature. A single screen design can have 1000 fields stacked as visual overlays up to 127 levels deep or as pop-ups. Groups of fields can be moved between levels. Screens can be output as compilable code or stored on disk for loading at run-time. Each field can be boxed, colored, multi-row, word-wrapped, and scrolled horizontally and vertically if larger than its on-screen view aperture. It can be assigned its own help and error message, can be told to accept certain characters, or to match a picture, and to check data after entry—proper dates, number ranges, etc.—using Panel's or your own validation routines. You can add your routines to Panel's test utility because even it comes as source. Fields are accessed in any order and control reverts to your application program after each field for choice of action.

For past Panelists, the new version has smaller and faster field and screen functions, tighter granularity, and an enhanced, reworked library. Major tool for the serious developer. List: **$495**, PC Brand: **$395**.

Shopping List for the Power Workbench

ASSEMBLERS & DEBUGGERS	LIST	US
Advanced Trace-86 *Morgan, ASM Interpreter*	175	119
C-Sprite Debugger *by Lattice, source level*	175	139
Microsoft Macro Assembler *with Utilities*	150	109
PASM86 *by Phoenix, Macro Assembler*	195	125
Periscope I Debugger *from The Periscope Co.*	345	299
Periscope II *w/NMI Breakout Switch*	175	139
Periscope II-X *software only*	145	105
Pfix86 Plus *by Phoenix, Symbolic Debugger*	395	235
BASIC LANGUAGE		
Microsoft BASIC Interpreter *for XENIX*	350	295
Microsoft QuickBASIC Compiler *full BASICA*	99	79
Professional BASIC *by Morgan*	99	69
BORLAND PRODUCTS		
Reflex & Reflex Workshop	200	129
Reflex *Data Base System*	150	89
Reflex Workshop	70	45
Turbo Basic......*New*	100	64
Turbo C Compiler......*New*	100	64
Turbo Lightning	100	64
Turbo Pascal & Tutor......*New*	125	85
Turbo Pascal with 8087 & BCD	100	64
Turbo Tutor	40	28
POLYTRON PRODUCTS		
PVCS Corporate...... *Source Code Control Syst.*	395	309
PVCS Personal	149	109
PVCS Network	Call	Call
PolyMake *Complete Make Utility*	149	109
PolyLibrarian *Library Manager*	99	73
PolyLibrarian II *Library Manaer*	149	109
PolyShell *UNIX-like Command Shell*	149	109
PolyXREF *Complete Cross Ref Utility*	219	169
PolyXREF *One language only*	129	99
PolyBoost *The Software Accelerator*	80	64
PolyDesk III *3rd Generation Desktop Org*	99	73
PolyDesk III *Add On Tools*	Call	Call
C COMPILERS		
C86 PLUS *by Computer Innovations......New*	497	397
Lattice C Compiler *from Lattice*	500	299
Let's C Compiler *by Mark Williams*	75	55
with CSD Source Level Debugger	125	90
MWC-86: Mark Williams C Development	495	369
Microsoft C Compiler *4.0*	450	295
C INTERPRETERS		
C-Terp *by Gimpel Software*	300	249
Instant C *by Rational Systems*	500	395
Interactive-C *by IMPACC with debugging*	249	219
RUN/C Professional *from Lifeboat*	250	185
RUN/C *without Loadable Libraries*	120	109
TEXT EDITORS		
Brief *from Solution Systems*	195	Call
Edix *by Emerging Tech...Multi-screen*	195	159
Epsilon *by Lugaru Software, like EMACS*	195	149
FirsTime *by Spruce Technology, C syntax*	295	229
Kedit *by Mansfield, similar to Xedit*	125	99
LSE, the Lattice Screen Editor *Multi Window*	125	100
Pmate *by Phoenix, with Macros*	195	115
Text Management Utilities *Grep, splat, diff, etc.*	120	100
Vedit *by Compuview*	150	99
Vedit Plus *by Compuview*	185	129
FILE MANAGERS		
Btrieve *by Softcraft, no royalties*	250	195
Btrieve Network *by Softcraft*	595	465
C-Tree *by FairCom - no royalties, source*	395	329
R-Tree *by FairCom-Report Generator*	295	245
C-Tree & R-Tree Combo *by FairCom*	650	541
dBC...*from Lattice...maintains DBASE files*	250	195
with source	500	390
dBC III Plus...*supports multi-user DBASE*	750	595
with source	1500	1185
dbVista *single user DBMS by Raima*	195	139
dbVista *multi-user DBMS*	495	399
Opt-Tech Sort *Can sort Btrieve files*	149	105

SCREEN DESIGN	LIST	US
Curses *by Lattice, UNIX screen designer*	125	99
with Source	250	199
Greenleaf Data Windows......*New*	225	169
with source	395	297
Panel Plus *by Round Hill, no royalties......New*	495	395
View Manager for C *by Blaise*	275	164
Vitamin C *by Creative Programming*	225	198
VC Screen *by Creative Programming*	100	81
Windows for C *Vermont Creative Software*	195	149
Windows for Data *includes Windows for C*	295	259
ZView *Data Management Consultants*	245	175
GRAPHICS		
Essential Graphics *by Essential, no royalties*	250	210
GSS Graphics Development Toolkit	495	375
GSS Kernel System *by Graphic Software*	495	375
GSS Metafile Interpreter	295	235
Halo *by Media Cybernetics*	300	219
with **Dr. Halo II**	440	299
Halo for Microsoft *includes all fonts*	595	434
COMMUNICATIONS		
Asynch Manager *by Blaise, for C or Pascal*	175	117
Greenleaf Communications *by Greenleaf*	185	139
PTel *by Phoenix, Binary File Communicator*	195	115
UTILITY LIBRARIES		
Blaise C Tools Plus	175	117
Blaise C Tools	125	84
Blaise C Tools 2	100	67
C Food Smorgasbord *by Lattice*	150	109
C Utility Library *by Essential, 300 functions*	185	139
Greenleaf Functions *by Greenleaf Software*	185	139
PforCe *by Phoenix, vast library*	395	235
DEVELOPMENT TOOLS		
Code Sifter *by David Smith Software, Profiler*	119	89
C-Worthy *by Custom Design Software*	295	269
C-Worthy for Network *Menus, help, errors*	495	449
Dan Bricklin's Demo Program *Prototyper*	75	69
LMK from Lattice *by Lattice, "make" like UNIX*	195	149
Microsoft Window Development Toolkit	500	365
PC-Lint *by Gimpel Software, after UNIX's "lint"*	139	125
PFinish *by Phoenix, EXE performance analyzer*	395	235
Plink86 Plus *Utilizes memory for overlays*	495	325
Pmaker *by Phoenix, like UNIX "make"*	125	85
Pre-C *by Phoenix, UNIX "lint"-alike*	295	155
Pfantasy Pac *six Phoenix products.....New Price*	995	Call
OTHER TOOLS		
BASTOC *by JMI, convert BASIC to C*	495	399
BASIC-C *BASIC's functions added to C*	175	139
Report Option *by Softcraft, Btrieve Report Gen.*	145	128
Xtrieve *by Softcraft, Query Utility for Btrieve*	245	220
FORTRAN COMPILERS & UTILITIES		
RM/FORTRAN *by Ryan McFarland*	595	Call
ACS Time Series *by Alpha Computer Service*	495	405
Forlib- Plus *by Alpha Computer Service*	70	45
Microsoft FORTRAN *Links with Microsoft C*	450	281
Microsoft FORTRAN *for XENIX*	695	546
Scientific Subroutine Package *by Alpha*	295	239
The Statistician *by Alpha Computer*	295	239
Strings & Things *by Alpha Computer*	70	45
OTHER LANGUAGES & UTILITIES		
RM/COBOL *by Ryan-McFarland*	950	Call
RM/COBOL 8X *ANSI 85 COBOL*	1250	Call
Source Print...*source code formatter*	75	60
Tree Diagrammer...*source code diagrammer*	55	45
Microsoft COBOL Compiler	700	499
Microsoft COBOL Compiler *for XENIX*	995	795
Microsoft COBOL Tools *with Source Debugger*	350	259
Microsoft COBOL Tools *for XENIX*	450	333
Microsoft Lisp *New Common Lisp*	250	189
Microsoft MuMath *includes MuSimp*	300	199
Microsoft Pascal Compiler *Links with M'soft C.*	300	199
Microsoft Pascal Compiler *for XENIX*	695	546
PDisk *Phoenix's new disk manager*	195	125

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PHOENIX POWER

PFORCE

Pfunction Pfestival

The ultimate integrated C library, offering everything from low level functions for hardware access to complete b-tree database management. Along the way are fundamentals for string manipulation, time/date calculations, field and screen editing, but also four styles of menus (Lotus included), windowing, background tasking, DOS interfaces, directory management, even interrupt-driven communications.

Beyond tools for application development are programmer utilities for disk library management, archiving and compilation. Design emphasizes objects so characteristics of windows, databases, records and fields can be established outside functions.

One large collection means consistent instructions, single index. PforCeTM has tutorials, examples, quick reference, and on-line help.

Everything in source, no royalties, all memory models of Lattice, M'soft. Specify: S0220 & Compiler. List: **$395**, PC Brand: **$235.**

Phantasmagoria! The list price of Phoenix's **Pfantasy Pac**—Pmate, Plink86 Plus, Pfix86 Plus, Pmaker, Pfinish, and Ptel combined—is now **$995.** Our price is better still. **Call!.**

PRE-C *Pick the Lint from Your Program*

Pre-CTM is like UNIX's "lint". It finds problems your compiler won't. Problems that a debugger will have trouble figuring out.

Compilers work with one module at a time. They don't see other modules which only meet at link time. Pre-C looks at *all segments of your program at once* and reports inter-module calamities: conflicting data type declarations; parameter lists in function calls which disagree with the functions themselves; machine-dependent expressions which inhibit portability, obsolete usage, casts with suspect conversions, variables never used, functions never called.

Adheres to Unix System III standard for portability. Ask for: P0590, List: **$295**, From Us: **$155.**

PLINK86 PLUS *Cached Overlays Maximize Memory Use*

Plink86TM shoehorns large programs into small machines by swapping program segments in from disk. Because modules share memory, a 512k program could run in a 128k machine, for example. But Plink86 is smarter than that: if it finds itself in a larger machine, it moves into leftover memory whatever program overlays will fit. Overlays now swap at memory speed not disk speed. Can automatically restore a displaced overlay to which a subsequently called overlay must now return, and can assign library modules either to the root segment or to overlay areas. Long indispensable to serious developers. Ask for: S0499. List: **$495**. Us: **$325.**

ZVIEW

Screen Design Aid

A complete package for screen design with full windows management as a bonus! Easy creation of screens with complex validation, such as range checking or required/optional data. Powerful Screen Paint utility for creating or editing applications screens. Built in security levels, set at run-time, control read or read/write access by field or screen. Automatic help screen processing for run-time aid per field or screen. Applications regain control during field tabbing, allowing run-time on-screen transaction processing or flow control. Run-time functions include Screen Read and Write with automatic transparent data conversion from screen image to data storage, Field Editing, Help Screen Processing, even a capability to change any field characteristic at run-time, plus Window Push Pop and Scroll. Versions for Lattice, Microsoft and Aztec C. Automatic free updates to registered users. No run-time royalties. List: **$245** PC Brand: **$175**

GSS GRAPHICS SYSTEM

Leave the Device Driving to GSS

ANSI CGI STANDARD!

GSSTM has reconfigured two components of its comprehensive graphics tools to conform with the ANSI Computer Graphics Interface (CGI) standard.

At the heart of the system is the Development Toolkit which contains all language interfaces and device drivers for keyboards, mice, joysticks, tablets, printers, plotters, cameras, and more. Drivers house management of vector graphics (plotters) and bitmaps used by raster input devices (scanners) to insulate the application program from concern for device idiosyncracy. No one else has implemented CGI that way. It means your programming remains generic; just switch drivers and the same program will drive a different device.

GSS KernelTM conforms to level 2b of ANSI's Graphical Kernel System (GKS) and contains all its needed drivers and language bindings. Kernel has macro level tools to draw and color an object, store the sequential instructions, and recreate the object on its own, as well as segment it, transform it, etc. So powerful, a single command may represent several score lower level statements.

Kernal has the tools for graph and chart generation and their captioning: hand it apples and oranges, say "pie", and it bakes the numbers into a digestible display for screen or plotters.

Kernel can convert the images it creates to ANSI Computer Graphics Metafiles (CGMs), a tokenized standard for storing every form of graphic image as data. The Metafile Interpreter reads the contents of a CGM and interprets it with full CGI capability for recreation on various devices.

Quality software? IBM thinks so. They sell the GSS series under their own label.

Unit royalties and annual fees have been instituted for redistribution. Needs 256k.

Ask for:	List	PC Brand:
GS010 CGI Dvlpmt Toolkit	**$495**	**$375**
GS020 Kernel System	**$495**	**$375**
GS040 Metafile Interpreter	**$295**	**$235**

LATTICE C COMPILER

The Most Widely Used C Compiler by Far

The compiler that put C on the PC. More programmers use Lattice than any other. Its huge libraries (325 functions!) enable the file-sharing and record-locking provisions of DOS 3.1, provide full transcendentals, and utilities to mimic the UNIXTM and XENIXTM environments. Embraces key UNIX enhancements: void functions, enumerated data types, data passing between structures by assignment. Defaults to the ANSI proposed standard, but command line options offer leniency. Also ANSI checking of external data types to swat bugs at link up.

You get small .EXE files, very fast link times and efficient aliasing. New options generate code to use 80186 and 80286 features; 88087 sensed and utilized. *PC Journal* review of 12 compilers called Lattice "a fine product to consider for the production of important applications." Ask for: S0100. List: **$500**, PC Brand: **$299.**

The DOLLAR is ON SALE!

Outside the United States? Our prices have plunged! Look what has happened to prices of programming tools in these major currencies:

		9/1/85	Press Time
Btrieve	DM	550	355
GSS Kernel	FF	3,200	2,260
Windows/Data	SF	600	389
C-Tree	Yen	78,500	46,980

We ship anywhere! So take advantage of a bargain. Phone or telex your order now. For credit cards, we need card number, expiry date, cardholder's name and address. Or wire funds (see "Payment" below). **We ship immediately.**

BLAISE *C Tools Plus*

Nothing pays you back quicker than a function library, and Blaise has long been known as a great one. C Tools Plus, the top of the line, now has over 200 functions. Mature, tight, predominantly in C, they isolate hardware dependence, come in source and library, with no royalty. The rundown:

Screen Handling: either via BIOS or direct to video adapter; supports EGA, 43-line mode and multiple pages, twin monitors. Windows: any number, stackable, writable, wordwrapable, and erasable. Interrupts: well known for interrupt service routines in C, from which you can now access DOS functions. Directories: Create, change, or search directories, rename files, get and change their date/times. Memory: control DOS memory allocation, load a "child" process alongside your program, even create memory-resident programs—and remove them. Strings: international money, dates and character sets, plus superfunctions to perform several tasks with a single call. General: BIOS and DOS gates for direct access, memory copy, speaker control, it goes on. Our complete Blaise line:

	List:	PC Brand:
C Tools Plus	**$175**	**$117**
Asynch Manager	**$175**	**$117**
View Manager	**$275**	**$164**
Turbo Asynch Plus	**$100**	**$ 67**
Turbo Power Tools+	**$100**	**$ 67**

BTRIEVE

ASK US ABOUT XTRIEVE & REPORT OPTION

Queen B-tree File Manager Abdicates Royalties

There's no longer a tithe to incorporate BtrieveTM in applications, a welcome proclamation if royalties would ruin your profit margins. Btrieve takes complete charge of all file creation, indexing, reading, writing, insertion, deletion, space recapture, forward and backward searching. It builds function call "commands" right into the language you use: interfaces to C, Pascal, BASIC, and COBOL, with sample programs in all four, come with each copy.

Btrieve has mainframe specifications! Its balanced-tree indexing scheme finds any key in a million in four or less accesses. Files may have up to 24 indexes; fixed record length to 4090 characters; indexes up to 255 characters; files of 4 billion bytes. Can even extend a file across two drives—even two hard disks!

Version 4.x speeds DOS interaction for large multiply-keyed files; enables variable length records of virtually any length; verifies accuracy (optionally) with read after write, useful in gritty environments; offers password and data encryption.

There's also Xtrieve, for Btrieve file inquiry and data manipulation, and Rtrieve for report writing. All three in versions for any network that supports the MS-DOS 3.1 file sharing function.

Ask for:	List:	PC Brand:
S0650	**$250**	**$195**
S0652 Network Version	**$595**	**$465**

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Licenses: Each price is for a license to use a product on a single computer and does not constitute its ownership. We will inquire for you about site licenses. Except as otherwise indicated or where "#" follows the Product Code, products may be used to create programs for distribution without royalty payments or additional licenses, provided said programs do not substantially replicate the products themselves.

Compatibility: PC BRAND's standard products are designed to operate with the IBM® PC, XT or AT under PC-DOS and require no more than 128k of RAM unless indicated. Non IBM machines using MS-DOS: contact manufacturer about precise differences so we can advise.

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Payment: We honor MasterCard, Visa, American Express (no surcharge), checks in advance, or funds wired to PC Brand, c/o Chemical Bank, 126 East 86 St., New York, Account 034-016058. COD (U.S. only) for cash, money order, certified check (no fee). NY State, add sales tax. Purchase orders accepted from larger corporations and institutions at our discretion if you agree to net 30 days plus 2% a month late penalty thereafter.

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Compatibility: The InColor Card is compatible with the thousands of programs that run on our monochrome cards.

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Hercules is known for bringing high resolution monochrome text and graphics to programs like 1-2-3® and AutoCAD®.

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All Hercules-compatible text, graphics and RamFont software runs on the InColor Card in black and white, or at least two colors.

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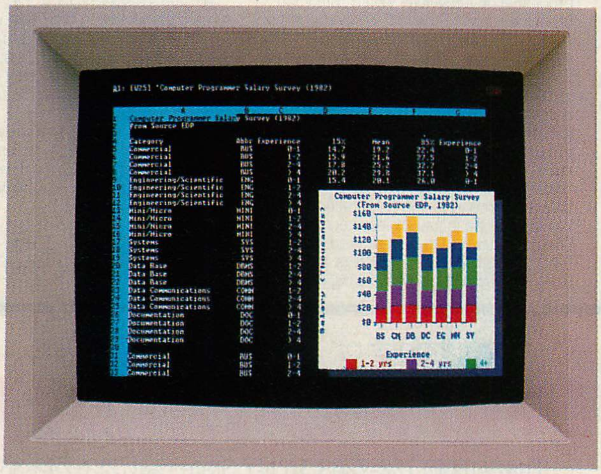
RamFont is a new mode developed by Hercules that gives your software the ability to display multiple fonts at lightning fast speeds.

RamFont transforms advanced word processors like Microsoft Word from slow to text-mode fast.

Technical word processors like Lotus Manuscript™ use RamFont



The InColor Card's RamFont mode gives Lotus 1-2-3 a pop-up graphics window and lets you view nearly twice as much spreadsheet data—all in full color.

to display onscreen the text you want to print.

Even 1-2-3 uses RamFont to almost double the size of the spreadsheet picture.

And now, with the InColor Card, you get an enhanced RamFont with 3,072 programmable characters in up to 16 colors.

All the way up to 12,288 characters in four colors.

With the InColor Card's RamFont, no program should run out of speed, color or fonts ever again.

AutoCAD gets the same high resolution 720x348 graphics as our famous monochrome cards—only now in full color on an IBM Enhanced Color Display.

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Without changing drivers.

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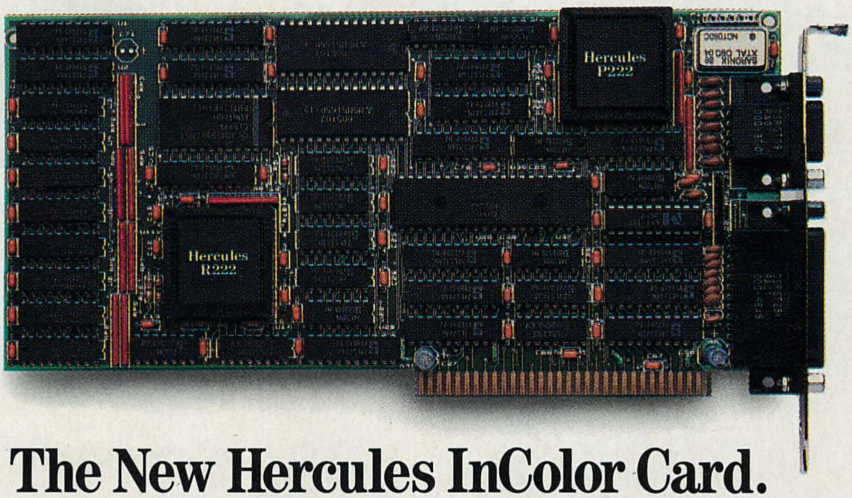
Call 1-800-532-0600, or 1-800-323-0601 in Canada, Ext. 511 to find out more on how the Hercules InColor Card can improve your software.

Features of the Hercules InColor Card

- Hi-res text with 9x14 character size in up to 16 colors with attributes
- 720x348 Hercules graphics in 16 colors selected from 64 color palette
- Special RamFont mode displays 3,072 programmable characters in 16 colors with attributes, up to 12,288 characters in 4 colors
- Runs Hercules-compatible graphics software in b&w or any two background colors
- Designed for use with the IBM Enhanced Color Display, multisync monitors, or equivalents
- Software diskette includes font editor, sample fonts, and Hercules utilities
- Parallel printer port
- Two year warranty



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FORTRAN Perspectives

One of the oldest high-level languages, FORTRAN continues to evolve, while maintaining strong standards. Seven compilers for the PC are reviewed here.

JOHN VOGLEWEDE

Among high-level computer languages, FORTRAN is a relatively ancient tongue. An acronym for formula translator, FORTRAN was introduced in 1954 and was first implemented on an IBM 704 in 1956. Within a few years, several versions of the new language were available.

Although those early versions of FORTRAN offered great flexibility in processing numerical data, their ability to manipulate strings or alphabetic data was marginal at best. Input and output (I/O) facilities were primitive. Language constructs such as the IF and GO TO statements resulted in abrupt shifts in program control from one area to another, making program flow difficult to follow and prone to error. But in spite of these limitations, the language flourished among mathematicians, scientists, and engineers because of its ability to handle numerical data easily. Later revisions to FORTRAN corrected many of the original shortcomings, and now modern FORTRAN allows character string manipulation and sophisticated control of I/O functions. In addition, the block IF and ELSE. . .IF statements have given the language a more structured character. By adapting to programming needs, FORTRAN has remained one of the most popular computer languages. Its portability and widespread use on mainframes make it a valuable tool for the microcomputer user.

FORTRAN compilers for the IBM PC were last reviewed in October 1985 (see "FORTRAN Options," Alan Howard,

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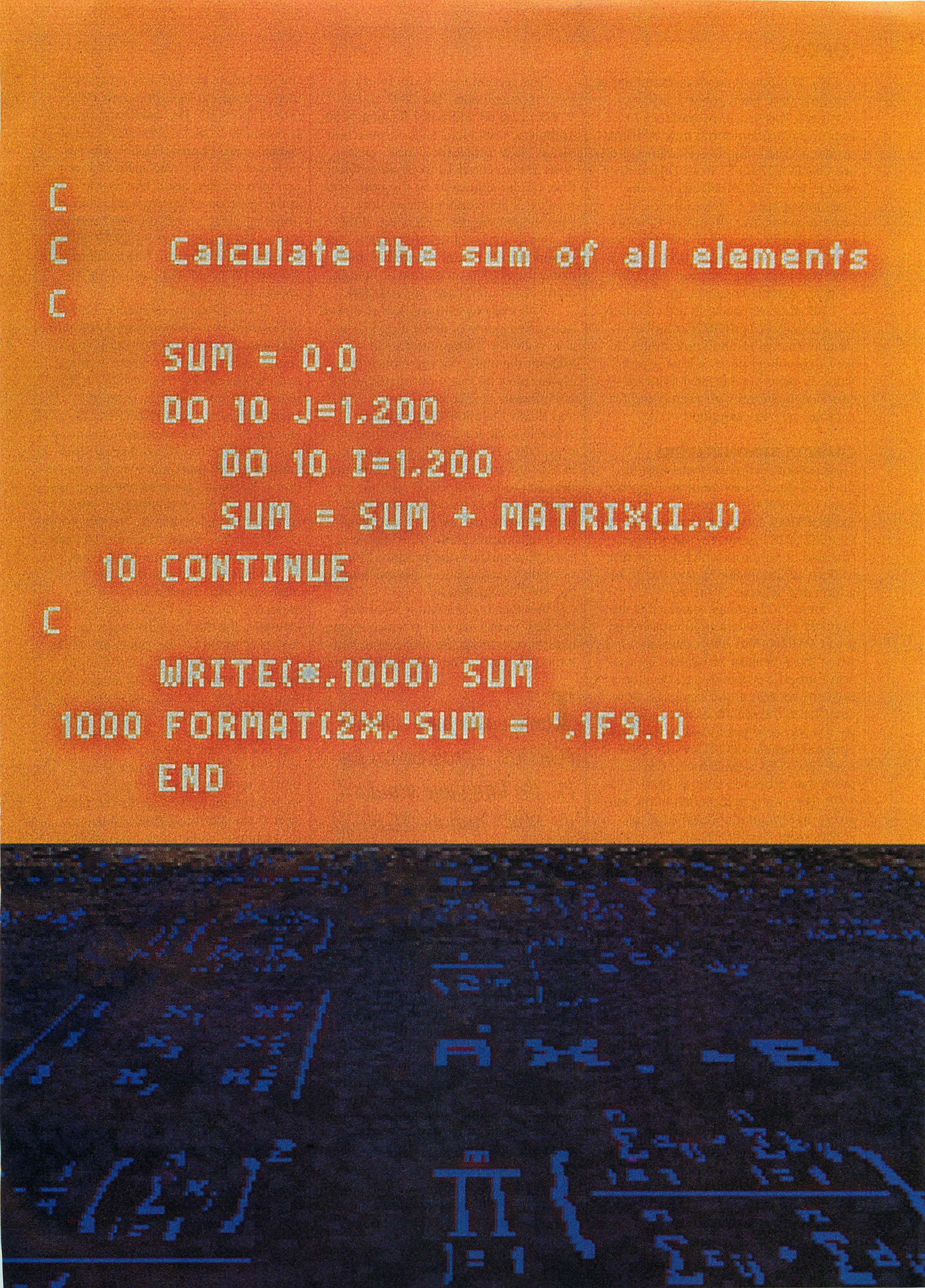

C
C Calculate the sum of all elements
C
SUM = 0.0
DO 10 J=1,200
DO 10 I=1,200
SUM = SUM + MATRIX(I,J)
10 CONTINUE
C
WRITE(*,1000) SUM
1000 FORMAT(2X,'SUM = ',1F9.1)
END

p. 149). The four compilers examined at that time have been revised, a few extensively. This article reexamines those four and considers three new FORTRAN products. The compilers examined here are DRI FORTRAN-77 from Digital Research, Inc., Utah FORTRAN by Ellis Computing, Inc., F77L by Lahey Computer Systems, Inc., Microsoft Corporation FORTRAN, Prospero Software's Pro FORTRAN-77, RM/FORTRAN by Ryan-McFarland Corporation, and WATFOR-77 from WATCOM Products, Inc.

All of these packages are commercial versions of FORTRAN compilers written for the PC and compatibles. A list of compiler specifications is provided in table 1; additional software products included with each compiler package are also identified.

COMMON DENOMINATORS

Three major technical issues have influenced the development and application of FORTRAN compilers on the PC: the FORTRAN language standard, the Intel 8087/80287 numeric coprocessors (the use of either of which is referred to here as simply 8087), and the 16-bit addressing scheme of the PC.

First, the language standard is an industry-wide specification established for FORTRAN. This effort dates to 1962, when the American Standards Association formed a committee to develop a uniform version of the language. Four years later, the results of the committee's work were published as American National Standard FORTRAN or ANSI X3.9-1966. This standard was revised more than a decade later as ANSI X3.9-1978. The two specifications of the language are commonly referred to as FORTRAN-66 and FORTRAN-77.

FORTRAN-77 describes two levels of the language: the complete standard and a subset thereof. Additional language features, or *extensions*, are permitted but are not part of the standard. Because portability is one of FORTRAN's strong points, adherence to the formal language standard can be considered an absolute requirement rather than simply a guide. Indeed, it is implemented by all but one of the compilers reviewed here (Ellis's Utah FORTRAN implements a subset of the FORTRAN-66 standard). A revision to ANSI FORTRAN-77, referred to as FORTRAN-8x, is currently under development. Details of the proposed standard suggest that it will bridge the gap between FORTRAN-77 and more modern programming languages, such as Pascal. Understandably, few of these compilers attempt to anticipate the new specification.

The second issue is the Intel numeric coprocessors. The 8087 and 80287 bring 68 additional floating-point arithmetic operations to the instruction set of a host processor. These operations are executed 10 to 50 times faster than can be simulated on the host. The result is a FORTRAN programmer's dream: lightning fast execution of the floating-point arithmetic instructions so common to FORTRAN. However, because the 8087 is an extra-cost option, many PCs do not have one installed.

The majority of compilers reviewed here are capable of generating executable code for configurations with or without the 8087, but sometimes the choice must be made during either the compilation or link step. Lahey's F77L and Ellis's Utah FORTRAN generate executable code for a single configuration only; DRI's FORTRAN-77, Microsoft FORTRAN, and RM/FORTRAN allow the decision to be postponed until the executable code is loaded. At that time, the executable file tests for the presence of a coprocessor; if present, it is used. Executable code produced for the non-8087 configuration also will run on the 8087 configuration.

Another consideration regarding the 8087 is the manner in which mathematical operations are carried out with the coprocessor. The 8087 performs all

Three issues have affected FORTRAN's progress on the PC: the language standard, the 8087, and the 16-bit addressing scheme of the PC.

of its calculations in an 80-bit, extended-precision format according to a proposed IEEE math standard. Because this data format does not match the 16-, 32-, or 64-bit formats normally encountered on the PC, certain rounding and conversion operations are used, again in conformance with the IEEE standard. The result is that floating-point operations are carried out in very high precision—approximately 18 decimal digits of accuracy. Single- and double-precision FORTRAN calculations, therefore, may have nearly identical runtimes and differ only in the extent to which the results are truncated.

In non-8087 configurations, the compiler must rely on floating-point library routines for the host processor that emulate the high-precision operation of the 8087. The emulation process is relatively slow, so abbreviated or alternate math library routines may be provided. The alternate math routines produce smaller, faster executable code at the expense of accuracy and calculational agreement with the 8087 configuration. The library options (8087, 8087 emulation, or alternate floating-point) that are provided with each compiler are shown in table 1.

The performance variance among the compilers is demonstrated in figure 1 as a display of code execution speed versus accuracy under various options and configurations. The results for this figure were produced by running a small program called PERFORM.F77 (listing 1), which repeatedly executes a set of intrinsic functions, through each compiler. The outcome of each iteration is known to be zero; therefore, the actual error can be determined and summed for all iterations. The precision of the result is simply the base-10 logarithm of the total accumulated error.

Under the constraints of the IEEE math standard, the results might be expected to cluster on the figure. For example, the 8087 results might be expected to fall on the right side while the non-8087 results would fall on the left. In a similar fashion, all single-precision results might lie in the lower half of the figure while all double-precision results land in the upper half. But this was not the case entirely.

The compilers' alternate math libraries tend to bridge the gap between each quadrant of the figure. The precision of the Microsoft 8087 emulation, for example, is the same, regardless of whether a single- or double-precision version of PERFORM.F77 was used. This is also true for Microsoft's actual 8087 version, thus indicating that operands are kept in the 8087 registers for nearly the entire operation. In this circumstance, the introduction of intermediate (even DOUBLE PRECISION) variables into the program leads to greatly reduced precision. The most important observation to be made from figure 1 is that a wide variation in FORTRAN performance is possible, even for a single compiler (using different options) or a single machine.

The final technical issue that has influenced the development and application of FORTRAN compilers on the PC is the machine's 16-bit addressing scheme. Quite simply, the PC's 16-bit processor does not readily access large amounts of memory, yet many pro-

TABLE 1: *Compiler Specifications*

	DRI	ELLIS	LAHEY	MICROSOFT	PROSPERO	RM	WATCOM
PRODUCT	FORTRAN-77	Utah FORTRAN	F77L	FORTRAN	Pro FORTRAN-77	RM/ FORTRAN	WATFOR-77
VERSION TESTED	4.1	1.0(4)	2.2	4.00A	1.141	2.11	1.4
PRICE	$350.00	$39.95	$477.00	$450.00	$149.00	$595.00	$375.00
SYSTEM REQUIREMENTS							
DOS version	2.0+	2.0+	2.0+	2.0+	2.1+	2.1+	2.0+
RAM (KB)	100	128	256	512	120	192	256
Numeric coprocessor [a]	Opt.	N/A	Req.	Opt.	XOR	Opt.	XOR
MEMORY MODEL							
64KB code	●	●	●	●	●	●	●
n*64KB code	●	○	●	●	●	●	●
640KB code	○	○	○	○	○	○	○
64KB data	●	32KB	●	●	●	●	●
n*64KB data	●	○	●	●	●	●	●
640KB data	○	○	●	●	●	●	●
COMPILER OPERATION							
Single-step compile	●	●	●	●	●	●	○
Compile and link	○	○	○	●	○	○	●
DOS path names	○	○	●	●	●	●	●
Multiple files	○	○	○	●	○	○	○
Wild cards	○	○	○	●	○	○	○
Source listing	●	●	●	●	●	●	●
Assembly language output	●	○	○	●	○	●	○
Line numbered messages	●	○	●	●	●	●	●
COMPILER DIRECTIVES							
Command line	●	●	●	●	●	●	●
Source file	●	●	●	●	●	●	●
Include	●	○	●	●	●	●	●
Nested	○	○	●	●	○	○	●
COMPILE OPTIONS							
Cross reference	○	○	●	○	Pgm.[b]	●	○
Subscript check	●	●	●	●	●	○	●
Call parameter check	○	○	●	○	○	○	○
Strict FORTRAN-77	○	○	○	●	○	○	●
Global SAVE	○	○	●	●	●	●	○
INTERFACE							
Assembly language	●	●	●	●	●	●	●
C language	●	—[c]	●	●	—[c]	—[c]	—[c]
Pascal	—[c]	—[c]	—[c]	●	●	—[c]	—[c]
80186/80286 inst.	○	○	○	●	●	●	○
LINKER OPTIONS							
Memory overlays	●	○	○	●	●	●	○
Preset data values	●	○	○	○	○	○	●
LIBRARY OPTIONS							
8087	●	○	●	●	●	●	●
8087 emulation	●	○	●	●	○	●	●
Alternate math	○	●	○	●	●	○	○
OTHER PROGRAMS							
Linker	●	●	○	●	●	●	●
Debugger	○	○	●	●	●	●	●
Source code editor	○	○	○	○	○	○	○
Librarian	●	○	○	○	●	○	●
Graphics	○	○	○	○	○	○	●

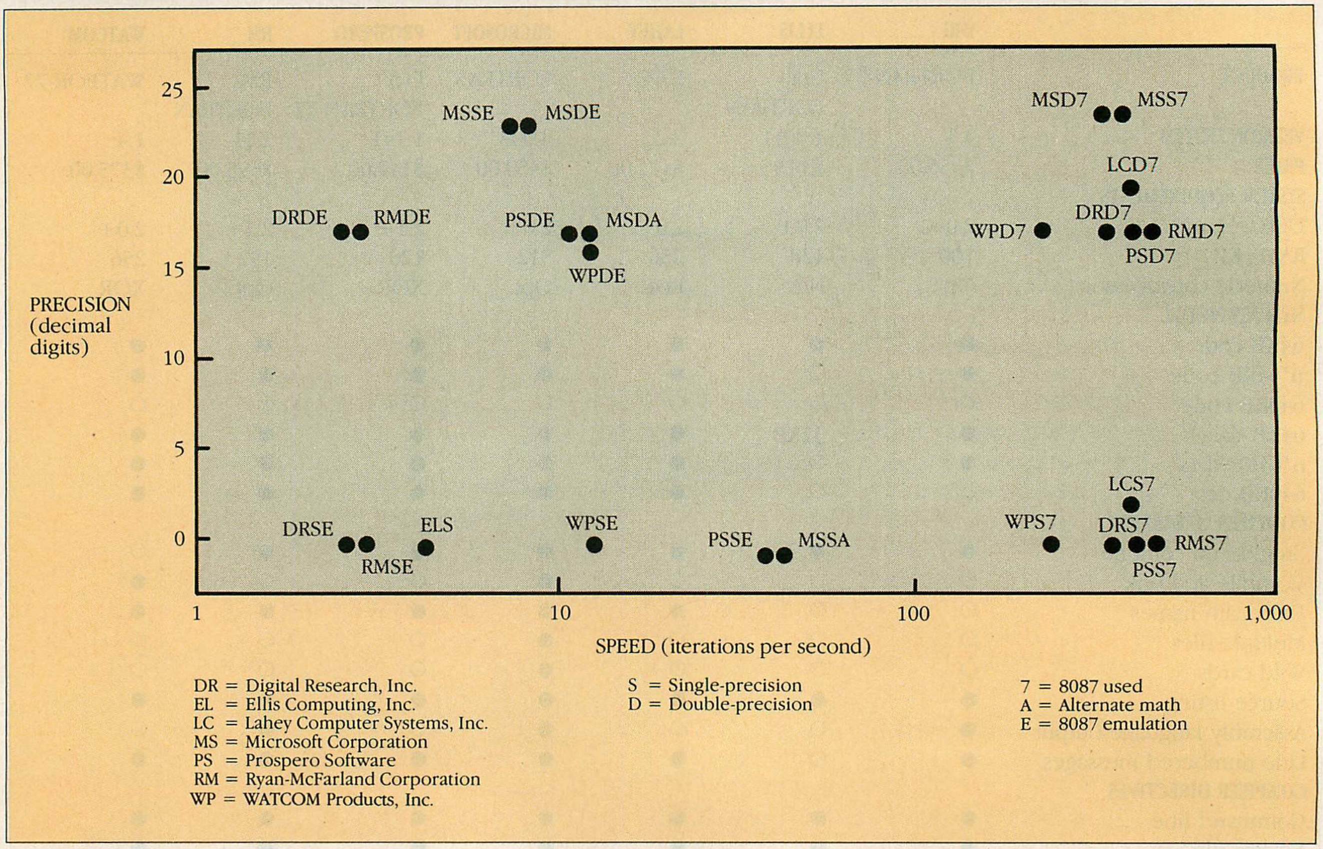
● = *Yes* ○ = *No*

[a] *Opt. = Optional (8087 will be used if present).*
N/A = Not applicable (8087 is ignored).
Req. = Required (8087 must be present).
XOR= Presence of 8087 must be determined prior to linking.

[b] *Separate program.*
[c] *Capability not discussed in documentation.*

Most of the compilers offer a choice between 8087 operation and 8087 emulation or alternate math routines. The two exceptions are the Lahey compiler, which requires an 8087 for its operation, and the Ellis product, which will not use an 8087 at all.

FIGURE 1: *Variations in Numerical Performance*



A wide variation is FORTRAN numerical performance is possible, even for a single compiler simply using different options.

grams in FORTRAN are memory-intensive. Because a 16-bit memory address can span only 64KB of memory (a segment), the compiler must rely on indirect means to access memory beyond that limit. This is accomplished by combining the 16-bit address within the segment (called the offset) with the 16-bit start-of-segment address—a process that complicates address calculation.

If the compiled code and the data used by the program were all resident in a single memory segment, all memory references could be based on a single 16-bit start-of-segment address register. In practice, FORTRAN compilers generate code and data segments separately. Several segments can be accessed as described, permitting large amounts of memory to be used.

In addition to the overhead from the complicated addressing scheme, the problem remains of allowing code or data to cross segment boundaries. Some compilers leave this issue to be resolved by the user. That is, code and data must be provided to the compiler in portions that are 64KB or smaller in size. For code, the restriction is not very significant because 64KB of executable code can be the result of several thousands of lines of source code. In addition, many 64KB program segments can be combined into a single executable file. For data, however, this restriction is quite significant. A single large array may require more than a single 64KB segment of memory. Other restrictions also may exist, such as a requirement to put arrays in named COMMON blocks.

The compilers reviewed here support a variety of memory models, thus the user can choose among trade-offs between memory access and execution speed. The 64KB code/64KB data memory models accommodate small programs and produce fast, efficient code. The larger (n*64KB and 1MB) memory models provide access to significantly more memory at the expense of execution speed. Although it is difficult to characterize the programmer's restrictions in a simple manner, the memory model descriptions provided by each vendor are summarized in table 1.

FEATURING FORTRAN

As noted, with the exception of Utah FORTRAN, all of these compilers conform to the full ANSI FORTRAN-77 standard, rather than the subset. (Table 2 lists the language features encompassed by each product.) The FORTRAN-66 and FORTRAN-77 standards share many common features; thus, each may be considered an informal subset of the other. To determine whether a compiler provides minimum support of the FORTRAN-66 standard, the compiler options were examined. If, during the test, it was possible to perform all DO loops at least once before the value of a DO variable was tested, the compiler was classified as an informal subset of FORTRAN-66. This is a definitive test because the FORTRAN-77 standard requires the DO variable to be tested prior to executing the DO loop.

Also listed in table 2 are a number of extensions to FORTRAN-77—free format source code and in-line comments, for example. FORTRAN-77 recognizes uppercase letters, digits, and 13 special characters. The special characters listed in the table for each compiler are in addition to those recognized by ANSI. All of these compilers accept upper- or lowercase input and, in some cases, distinguish between the two for certain language constructs. The IMPLICIT NONE statement is a particularly useful extension—a nonstandard

TABLE 2: *Language Features*

	DRI	ELLIS	LAHEY	MICROSOFT	PROSPERO	RM	WATCOM
PRODUCT	FORTRAN-77	Utah FORTRAN	F77L	FORTRAN	Pro FORTRAN-77	RM/ FORTRAN	WATFOR-77
VERSION TESTED	4.1	1.0(4)	2.2	4.00A	1.141	2.11	1.4
ANSI LEVEL							
FORTRAN-66	Subset	Subset	None [a]	Subset	None [a]	Subset	None [a]
FORTRAN-77	Full	— [b]	Full	Full	Full	Full	Full
SOURCE CODE FORMAT							
Free format	●	○	●	●	○	●	○
In-line comments	○	○	●	●	○	○	○
DATA TYPES							
INTEGER	1/2/4/8	— [c]	2/4	1/2/4	1/2/4	2/4	1/2/4
REAL	4/8/10	— [c]	4/8	4/8	4/8	4/8	4/8
DOUBLE PRECISION	8	— [c]	8	8	8	8	8
LOGICAL	1	6	1/4	1/2/4	1/2/4	1/4	1/4
COMPLEX	8/16/20	— [d]	8/16	8/16	8	8/16	8/16
DECIMAL	—	6	—	—	—	—	—
CHARACTER	<65,536	<7	<65,281	<32,768	<256	<256	<65,536
IMPLICIT NONE	○	○	●	●	●	○	○
Variable name length	40	6	31	31	6	31	32
INPUT/OUTPUT							
List-directed I/O	●	●	●	●	●	●	●
Internal I/O	●	○	●	●	●	●	●
NAMELIST	○	○	●	○	○	○	○
EDIT DESCRIPTIONS							
A	●	●	●	●	●	●	●
B (binary)	○	●	○	○	○	○	○
BN/BZ	●	○	●	●	●	●	●
D	●	●	●	●	●	●	●
E	●	●	●	●	●	●	●
F	●	●	●	●	●	●	●
G	●	●	●	●	●	●	●
Hollerith	●	○	●	●	●	●	●
I	●	●	●	●	●	●	●
L	●	●	●	●	●	●	●
O (octal)	●	○	○	○	○	○	○
P	●	○	●	●	●	●	●
S/SP/SS	●	○	●	●	●	●	●
T/TL/TR	●	●	●	●	●	●	●
X	●	●	●	●	●	●	●
Z (hex)	●	●	●	●	○	●	●
CHARACTER SET							
Lowercase	●	●	●	●	●	●	●
Nonstandard characters	%_	#&\''	''_&<>!	ASCII	None	None	None
NONSTANDARD FUNCTIONS							
Bit manipulation	○	●	●	●	○	●	○
Complex*16 operators	○	○	●	●	○	●	●
Date/time	○	●	●	●	●	Asm.[e]	Asm.[e]
DOS interface	○	●	●	○	●	○	●
RAM operators	○	●	●	●	●	○	○
Random numbers	○	●	●	○	●	○	○
Chaining	○	●	●	○	DOS[f]	○	○
String operators	○	●	●	○	○	○	○

● = *Yes* ○ = *No*

[a] *Does not support special FORTRAN-66 constructs.*
[b] *Utah FORTRAN does not support FORTRAN-77.*
[c] *Stored in six-byte binary-coded-decimal format.*
[d] *Not supported.*
[e] *Must use assembly language to access date and time; calling routines are provided.*
[f] *Pro FORTRAN-77 allows access to most DOS commands, including chaining.*

All of these compilers except Ellis's Utah FORTRAN implement the complete ANSI FORTRAN-77 language standard, not a subset. Users, therefore, are free to consider the finer points in an implementation when choosing a compiler.

TABLE 3: *Documentation Quality*

	DRI	ELLIS	LAHEY	MICROSOFT	PROSPERO	RM	WATCOM
PRODUCT	FORTRAN-77	Utah FORTRAN	F77L	FORTRAN	Pro FORTRAN-77	RM/ FORTRAN	WATFOR-77
PROGRAM PACKAGE							
Number of disks	2	1	2	7	3	3	3
Packing list	○	○	○	On disk	●	○	●
Disk file inventory	●	●	●	●	●	●	●
File description	●	●	●	●	●	●	●
Sample programs	●	●	●	●	●	●	●
Quick reference card	●	○	○	●	○	●	●
Index tabs	●	○	●	●	●	●	○
Tech. support number	● [a]	○	●	●	○	●	●
MANUAL ORGANIZATION							
Table of contents	●	●	●	●	●	●	●
Functional index	●	●	●	●	●	●	●
Language section							
FORTRAN concepts	●	○	○	○	●	●	○
Operations section	●	●	●	●	●	●	●
INSTALLATION							
Installation guide	●	●	●	●	●	●	○
Auto installation	○	○	●	●	○	○	○
RAM disk procedure	○	○	○	●	○	○	○
Copy protection	○	○	○	○	○	○	●
OPERATIONS EXPLAINED							
Compile options	●	●	●	●	●	●	●
Compiler limits	●	●	●	●	●	●	●
Compiler error list	On disk	●	●	●	●	●	●
Link options	●	○	○	●	●	●	●
Linker limits	○	○	○	●	○	○	●
Link error list	●	○	○	●	●	●	●
Execution options	○	●	○	○	○	●	○
Execution error list	●	●	●	●	●	●	●
Memory models	●	○	●	●	●	○	○
Memory layout	●	○	●	●	●	○	●
LANGUAGE SPECIFICATIONS							
Revision notice	●	○	●	●	●	○	●
FORTRAN-77 extensions	●	○	●	●	●	●	●
Internal data format	●	●	○	○	●	●	●
LICENSE AGREEMENT							
Runtime distribution	○	○	○	○	●	●	Site [b]
Without permission	●	●	●	●	— [c]	— [c]	○
Without royalty	●	●	●	●	— [c]	— [c]	●
Without copyright notice	○	○	●	○	— [c]	— [c]	○

● = *Yes* ○ = *No*

[a] *Technical support beyond warranty for a fee.*
[b] *Available to site-licensed users only.*
[c] *Runtime distribution not permitted under any condition.*

Each vendor attempts to identify its extensions to FORTRAN-77, but the extent to which this is achieved is sporadic. Microsoft's approach is a successful one—its documentation identifies all extensions to the standard language with a different color type.

method of requiring explicit declaration of variables to aid in the detection of misspelled variable names. (This construct is one that could be included in the ANSI FORTRAN-8x standard.)

Type declarations for variables are defined in FORTRAN-77, but data type lengths are not. For example, REAL is a legal statement in FORTRAN-77, whereas REAL*4 is an extension that is recognized by most FORTRAN compilers. FORTRAN-77 requires a common but unspecified length for both REAL and INTEGER data types. If the default length of a REAL variable is four bytes, the default length of an INTEGER variable also must be four bytes.

An overview of the compiler documentation is provided in table 3. The volume of documentation included in these packages ranges from a single soft-cover booklet (Ellis Utah FORTRAN) to three full-size instruction manuals (Microsoft FORTRAN); however, quantity and quality are not always correlated. For example, Prospero bundles its half-filled Pro FORTRAN-77 binder with a foam insert to keep it from collapsing, but the material is lucid and comprehensive in spite of its brevity.

Essentially, each vendor has made an effort to identify its extensions to the ANSI FORTRAN-77 standard, but the extent to which this is accomplished is sporadic. Microsoft's approach seems to be the most successful—its documentation identifies all extensions to the standard language with a different color of type. In addition, Microsoft is joined by WATCOM in offering a strict FORTRAN-77 language interpretation (no extensions) as a compiler option.

License agreements also offer insight into software products. Several of these vendors unilaterally offer runtime distribution privileges for executable files created with their product. In those cases where runtime distribution privileges may be granted, prior authorization in writing, royalty payments to the vendor, or disclosure of the vendor's copyright notice in the runtime product and its distribution diskette could be required. Table 3 indicates some of these license conditions. However, users considering development of commercial applications using one of these FORTRAN compilers should do so only after reading the applicable license agreement in detail.

SPECIFIC PERFORMANCE

Rather than carrying out the customary timing benchmarks (Sieve of Eratosthenes, Whetstone), the set used here was developed to evaluate specific areas of compiler performance. As any set of benchmarks is necessarily limited, some of the liabilities of this series are discussed along the way.

The first benchmark, MINIMUM.F77 (listing 2), is simply an END statement. Although it seems an extremely trivial one, MINIMUM gives an indication of the overhead required to perform both a compilation and link with a minimum executable program size. This benchmark represents the smallest legal program in FORTRAN-77.

SYNTH1.F77 (listing 3) is an artificial approximation of a typical, small FORTRAN program. It involves no loops or subprogram calls. Four REAL variables are provided with initial values by means of a DATA statement. During program execution, a sequential set of 20 statements is encountered. Each statement uses a simple arithmetic operator (+, –, *, or /) to define a new REAL variable on the basis of two previously calculated values. At the end of the program, the results of the calculation sequence are displayed.

The third and fourth benchmarks, SYNTH2.F77 and SYNTH3.F77, are extensions of the previous test (because these two programs are simply repetitions of SYNTH1, the actual code is not listed here). SYNTH2 contains 200 statements in the sequential series. SYNTH3, which contains 2,000 statements in the same series, is code- rather than data-intensive. Although the 2,007-line main routine is a poor example of programming style, technically it is permitted in FORTRAN-77. Indeed, such examples are encountered in actual practice. The SYNTH3 program contains 2,000 arithmetic statements, 2,004 REAL variables, and 250 arithmetic operations of each basic type (+, –, *, and /).

ITERATE.F77 (listing 4) is also similar to the previous benchmarks. Four REAL variables are defined and provided initial values via a DATA statement. However, the sequence of the basic four arithmetic operations is now placed in a nested DO loop and performed 1 million times. As shown in the listing, a double set of DO-loop indexes is used to avoid possible numerical overflow if two-byte integer, DO-loop variables are used. An auxiliary sequence of the four additional arithmetic statements has been added to the iteration in order to redefine all variables within the loop. This was done to prevent an overly zealous optimizer from reducing the loop to a single-pass procedure. The extra statements in the loop bring the total number of operations to 8 million—2 million each of additions, subtractions, multiplications, and divisions. The cumulative results of the iteration are displayed in order to assure that the calculations have been performed correctly.

Nearly all of the compilers overlooked one error in listing 6—the uninitialized variable SUM appears on both sides of an expression.

The next benchmark, BIGARRAY (listing 5), contains a (200-by-200) 40,000-element REAL array that is provided with a set of initial conditions by a DATA statement. All elements are added up and the result displayed. The program is quite short, at only 22 lines of source code; however, at four bytes per element, the 160KB array is significantly larger than the 64KB segment size limit of the PC.

Listing 6, the BIGERROR.F77 benchmark, is a replicate of BIGARRAY, identical in length and number of statements, but with several syntactic and grammatical errors introduced. It serves to evaluate compiler error-detection capabilities. The listing can be considered in conjunction with the comments to BIGERROR, printed directly below the listing itself. These comments describe the type and location of the errors. Some of the errors are subtle and ordinarily would be detected only during program execution, rather than during compilation or linking. Nearly all of these compilers overlooked the error in line 14, in which the uninitialized variable SUM appears on both the right- and left-hand sides of an expression.

OPTIONS WEIGHED

The machine used to compile, link, and execute the benchmarks was a Columbia Data Products MPC with a 4.77-MHz 8088/8087, 640KB RAM, one double-sided/double-density diskette drive, and a 20MB hard-disk drive. The system was running DOS 3.2. The system configuration used was FILES=20, BUFFERS=15, and all operations were timed using DOS TIME. The individual benchmark results include a small overhead for the timing operation itself. However, they also encompass program loading and subsequent I/O from the hard-disk drive, which, during compilation and linking, tended to be busy. These performance figures represent typical compile, link, and execution times for the system described. Users with diskette-based or RAM-disk-based systems should expect disparate results.

Separate 8087 and non-8087 executable files were generated, even in those cases where a compiler could produce executable files that detect the presence of the 8087 and use it (DRI and Microsoft). The non-8087 timings are included in table 4. Where small memory models or selective linking features were offered, these were used as well; large memory models were used only when necessary. No changes in the source code benchmarks were made except as mentioned in the text.

Each of these compilers can be run in a number of ways. The Microsoft compiler, for example, offers three memory models, three floating-point math libraries, and two methods for including floating-point instructions. The sheer number of combinations precludes listing compile, link, and execution times for all configurations.

Alternate math libraries were not used if avoidable. Their use naturally

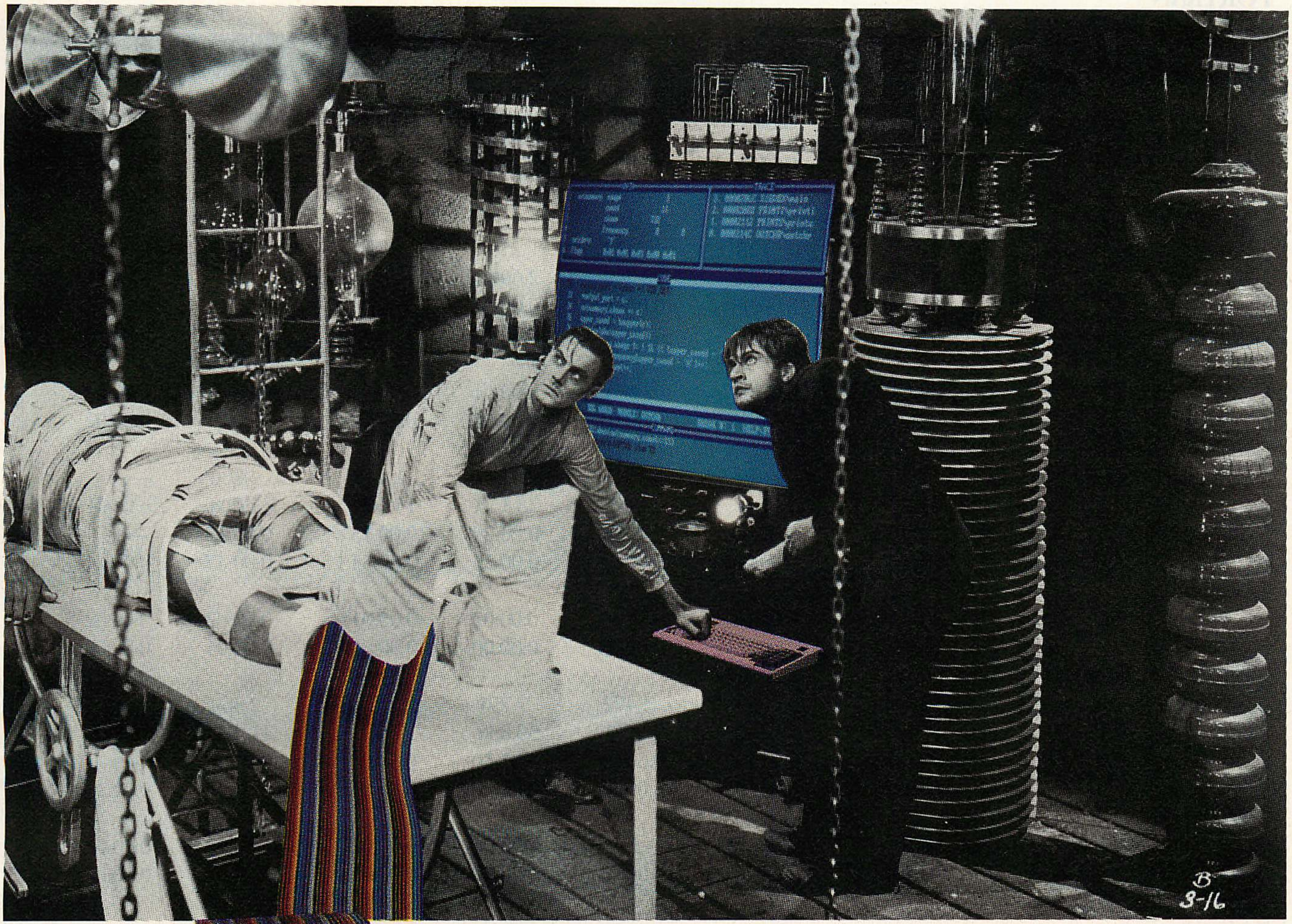


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TABLE 4: *Performance Benchmarks*

	DRI	ELLIS	LAHEY	MICROSOFT	PROSPERO	RM	WATCOM
PRODUCT	FORTRAN-77	Utah FORTRAN	F77L	FORTRAN	Pro FORTRAN-77	RM/ FORTRAN	WATFOR-77
MINIMUM (1 line)							
Compiled size	198	128	322	250	272	268	— [a]
Linked size	34,304	21,632	12,749	2,606	7,680	14,976	62,480
Compile time	0:00:09	0:00:05	0:00:07	0:00:07	0:00:04	0:00:07	— [a]
Link time	0:00:58	0:00:04	0:00:17	0:00:10	0:00:33	0:00:22	0:00:10
Runtime							
Without 8087	0:00:01	0:00:01	— [b]	0:00:01	0:00:01	0:00:01	0:00:02
With 8087	0:00:01	— [c]	0:00:01	0:00:01	0:00:01	0:00:01	0:00:02
SYNTH1 (27 lines)							
Compiled size	1,667	640	822	1,190	1,443	866	— [a]
Linked size	51,072	22,144	24,175	28,150	13,568	39,008	63,248
Compile time	0:00:12	0:00:09	0:00:09	0:00:29	0:00:13	0:00:18	— [a]
Link time	0:01:19	0:00:04	0:00:24	0:00:26	0:00:54	0:00:47	0:00:11
Runtime							
Without 8087	0:00:02	0:00:01	— [b]	0:00:02	0:00:01	0:00:02	0:00:02
With 8087	0:00:02	— [c]	0:00:03	0:00:00	0:00:01	0:00:01	0:00:02
SYNTH2 (207 lines)							
Compiled size	12,168	4,736	3,477	7,791	9,752	2,860	— [a]
Linked size	55,296	26,240	26,751	30,838	17,408	41,712	68,288
Compile time	0:00:36	0:01:01	0:00:29	0:01:30	0:01:07	0:01:38	— [a]
Link time	0:01:26	0:00:06	0:00:26	0:00:28	0:01:04	0:00:47	0:00:21
Runtime							
Without 8087	0:00:04	0:00:03	— [b]	0:00:02	0:00:01	0:00:02	0:00:02
With 8087	0:00:02	— [c]	0:00:03	0:00:02	0:00:01	0:00:01	0:00:02
SYNTH3 (2,007 lines)							
Compiled size	Error [d]	Error [d]	30,386	86,007	Error [d]	Error [d]	Error [d]
Linked size	—	—	52,847	61,862	—	—	—
Compile time	—	—	0:10:23	0:11:50	—	—	—
Link time	—	—	0:00:33	0:00:49	—	—	—

would result in faster execution times for some of the problems presented. In this article and its accompanying table, a non-8087 library was listed as 8087 emulation or alternate math, based on the vendor's documentation. If the library type was not identified, the table entry was based on the results of a set of deeply nested intrinsic function calculations. If the result of the 8087 and non-8087 calculations were in reasonable agreement, the non-8087 library was declared to be an 8087 emulation.

Digital Research, Inc. DRI's FORTRAN-77 is a complete implementation of the ANSI standard (as it was when reviewed in the previous article). The compiler supports a number of options, including free-field format source code, subscript checking, and several memory configurations, and it is one of the easiest of these packages to use. Documentation for version 4.1 of this compiler states that DOS path names are supported, but it was not possible to compile or link without all files being resident in the same subdirectory. In addition, the FORTRAN cross-reference option is claimed as available, but the feature has not yet been implemented.

The DRI user's manual also indicates that its FORTRAN-77 can address 1MB of combined code and data; however, the product was unable to complete SYNTH3 and BIGARRAY, the two memory-intensive benchmark problems. For the former, the compiler processed several hundred lines of source code before expiring due to a nonspecific "out of memory" error. For BIGARRAY, which employs a 160KB array, compilation was successfully completed, but the object module failed to link. The manual suggests that matrices of up to 65,535 elements can be created. It further states that "You must compile programs that use arrays larger than 64KB with the large model and the -V [subscript check] option. Each large array must be in a separately named COMMON segment, not in blank COMMON." By modifying BIGARRAY to accommodate the COMMON directive, the program was compiled and linked successfully, however, it produced incorrect results when executed. Its calculated sum of the array elements (99,920) was somewhat less than it should have been (100,000).

The default integer size used by this compiler is two bytes. This small data format can lead to numerical overflow (refer back to the description of program ITERATE); moreover, it does not conform to the ANSI standard (integer and real data formats must be the same length). Fortunately, the implicit integer size can be changed by compiler option and this was done for the benchmark calculations.

One of most noteworthy features of DRI FORTRAN-77 is the availability of extended precision INTEGER, REAL, and COMPLEX data formats. Although support of these formats is quite limited (for example, very few extended-precision intrinsic functions are offered), DRI comes the closest to matching the 80-bit format of the 8087.

The package includes an overlay linker, but not a debugger: users must rely on IBM DEBUG. Although the

	DRI	ELLIS	LAHEY	MICROSOFT	PROSPERO	RM	WATCOM
SYNTH3 (continued)							
Runtime							
Without 8087	—	—	—[b]	0:00:05	—	—	—
With 8087	—	—	0:00:04	0:00:02	—	—	—
ITERATE (23 lines)							
Compiled size	1,308	512	737	816	1,013	733	—[a]
Linked size	51,072	22,016	24,095	28,006	13,312	38,864	62,960
Compile time	0:00:12	0:00:09	0:00:09	0:00:28	0:00:10	0:00:14	—[a]
Link time	0:01:18	0:00:04	0:00:25	0:00:26	0:00:54	0:00:46	0:00:10
Runtime							
Without 8087	18:46:33	7:40:31	—[b]	3:16:05	0:48:49	11:49:25	0:58:11
With 8087	0:10:58	—[c]	0:08:44	0:06:25	0:09:12	0:07:46	0:21:06
BIGARRAY (22 lines)							
Compiled size	Error[d]	Error[d]	791	857	1,030	161,875	—[a]
Linked size	—	—	184,399	187,974	14,336	198,848	222,832
Compile time	—	—	0:00:08	0:00:25	0:00:10	0:28:10	—[a]
Link time	—	—	0:01:00	0:01:03	0:00:57	0:01:14	0:00:13
Runtime							
Without 8087	—	—	—[b]	0:01:06	0:01:00	0:03:16	0:01:04
With 8087	—	—	Error[d]	0:00:08	0:00:44	0:00:08	0:00:52
BIGERROR (22 lines) (Number of errors detected)							
Compilation	6	9	10	12	11	8	8
Execution	2	0	1	1	1	0	6
Passes required	6	4	4	5	5	3	10
Errors undetected	6	5	3	1	2	6	0
Error numbers[e]	1,3,4 14,17,20	10,14,16 17,20	1,10,14	14	14,17	3,4,14 15,16,17	None

All files sizes are in bytes.
All times are in hours:minutes:seconds.

[a] *Single-step compile and link only.*
[b] *F77L requires the 8087 coprocessor.*
[c] *Utah FORTRAN does not support the 8087 coprocessor.*

[d] *Product unable to complete benchmark. See text regarding individual compilers.*
[e] *See program listing.*

Most of these products had trouble compiling the SYNTH3 benchmark—a code-intensive, 2,007-line extension of SYNTH1.

linker is somewhat sluggish compared with the others, it does support a runtime option of using the 8087.

Ellis Computing, Inc. At $39.95, Ellis's Utah FORTRAN is the lowest-priced compiler in the field, but it does not conform to ANSI FORTRAN-77 guidelines. The vendor states that the compiler is "both a subset and a superset of the ANSI-66 standard." More precisely, Utah FORTRAN is a subset of the older FORTRAN-66 standard with several extensions added. The extensions include the IF. . .THEN. . .ELSE construct from the more recent FORTRAN-77 standard.

Utah FORTRAN features a global program-tracing facility, access to absolute memory locations (PEEK and POKE), bit manipulation, memory-to-memory I/O operations (ENCODE and DECODE), and the ability to chain a series of programs. This compiler retains sufficient similarity to the modern FORTRAN language to compile and execute the four smaller benchmark programs. However, it was necessary to modify WRITE statements in each benchmark program to compile them successfully; that is, a WRITE statement of the form WRITE(*,1000) had to be changed to WRITE(1,1000).

In another departure from the ground rules, a source code OPTION statement had to be employed to increase the compiler symbol table size from its default value of 200. This change was adequate to successfully compile the SYNTH2 benchmark, but not SYNTH3. Utah FORTRAN also was unable to compile BIGARRAY, with its 160KB array, due to its 32KB limit on such constructs; however, the manual offers suggestions to get around this limit (by putting smaller arrays adjacent to each other in COMMON).

A startling deviation from the other compilers is Utah's storage of all REAL, INTEGER, and DOUBLE PRECISION variables as six-byte, binary-coded-decimal numbers. This practice allows high-precision level for fiscal calculations, but does not consider the more conventional distinction between INTEGER and REAL numbers permitted by FORTRAN. Statement functions, and the EXTERNAL and EQUIVALENCE statements, also are missing.

During compilation and execution, Utah FORTRAN functions much like an intermediate code interpreter. The object files produced by the compiler are not linked, but executed directly by a runtime supervisor that supplies intrinsic functions, subroutines, and other library references. If stand-alone, executable code is desired, another vendor-supplied utility is invoked that binds the compiled program with the runtime library. The result is an executable file that "cannot be renamed and must exist in the directory where the program [was created]." The bottom line on Utah FORTRAN is that, for simple programs, it does work and work quite well. It may be a good deal for the money.

Lahey Computer Systems, Inc. A strong contender in the previous review, Lahey continues to offer a solid product in its F77L compiler. The package includes the compiler, an 8087 library, and a debugging utility called Source On-Line

Debugger (SOLD). The debugger allows the programmer to view his source code, monitor program execution, and examine, modify, and trace the value of variables. SOLD does not require recompiling or relinking because it interfaces with the production-compiled programs. A linker is not provided with F77L, but DOS LINK version 2.4 was used with no problem. This is the only compiler that *requires* an 8087 or 80287 to be present for both compilation and execution. In addition, Lahey has made a couple of interesting departures from the standard language for the user's benefit. First, F77L provides the IMPLICIT NONE construct mentioned earlier, and second, in-line comments and NAMELIST I/O are supported.

The Lahey license agreement is exceptionally fair and reasonable. The agreement states that executable files, including library modules, are not subject to usage or transfer restrictions, that no additional costs are associated with distributing runtime files, and that files need not include the Lahey copyright notice. It is the most liberal license agreement of those reviewed. The technical support telephone number, an electronic bulletin board, a users' newsletter, and an included mailer for problem diskettes attest to Lahey's leadership in the area of user support.

The performance of F77L in the benchmarks was quite good overall, but its error-detection capabilities are only average. The compiler actually ran all of the benchmarks, but produced an incorrect result for BIGARRAY. In order to properly assess the F77L compiler, the array size in BIGARRAY was reduced to 100 by 100. This smaller program did compile and execute properly. The errors in BIGERROR then were introduced into this smaller program. The compilation of the modified BIGERROR benchmark missed two subtle errors: the multiple program names and the missing initial value of SUM.

F77L's problem with BIGARRAY seemed to be the DATA statement in line 10 of that program. The Lahey documentation states that the repeat count in a DATA initialization statement must not exceed 16,383. Although the individual repeat counts did not exceed this limit, the total for the DATA statement did. By reducing the repeat count below this limit (but greater than the storage size available in array) the statement was able to compile without error, but produced incorrect results. It likewise compiled without error and produced incorrect results when the total repeat count was greater than 16,383, and the number of initial values was equal to the number of elements to be initialized. Evidently, the compiler cannot reliably process DATA statements that have a total repeat count greater than 16,383. The repeat count limit is a minor matter; the compiler's inability to determine when that limit is exceeded can lead to erroneous execution of compiled programs.

Microsoft Corporation. The sheer volume of material that comes with the Microsoft FORTRAN package (three binders and seven diskettes) can be overwhelming, and the 512KB RAM requirement puts this compiler in a league by itself. But this product has been improved radically since version 3.3 (reviewed in October 1985) to the current 4.0.

Perhaps the biggest change is that Microsoft FORTRAN now complies with the ANSI FORTRAN-77 full language standard rather than the subset. This move required significant changes to the compiler, including the addition of several new intrinsic functions. As a typical example, the maximum length of a CHARACTER variable has been increased from 127 to 32,767 bytes. Some previously included features, such as the decimal math library, have been removed. A noteworthy addition is Microsoft's source-code and assembly-language-level debugger, CodeView (reviewed in "Multilevel Debugger," Mark S. Ackerman, March, 1987, p. 90).

Microsoft FORTRAN now complies with the full language standard. This current implementation does almost everything well.

This compiler is not for the casual user. Installation is complicated and invites user errors, particularly when used a dual-diskette system. Microsoft FORTRAN offers three memory models (medium, large, and huge), three floating-point math libraries (8087, 8087 emulator, and alternate math), and two methods of using floating-point instructions (in-line instructions or calls to the floating-point library routines). Although not all possible combinations of these compiler options are meaningful, the list does indicate the considerable number of choices available and that some thought must precede invoking the compiler. Along the same line, the auto-installation procedures that are included in the set-up disk appear to be a matter of necessity rather than one of convenience.

This implementation of FORTRAN seems to do almost everything well. Its shortcomings are minor—the lack of a cross-reference option, for example, and the fact that compiler directives are case-sensitive. The product's new features, such as the previously mentioned highlighting of the extensions to ANSI FORTRAN-77 in the documentation, seem to offset its imperfections. The compiler also now includes an option to make it function in strict compliance to the ANSI standard (with no extensions). Microsoft FORTRAN 4.0 is certified by the U.S. General Services Administration (GSA) to be in full compliance with the FORTRAN-77 standard.

Finally, this compiler was the only one that successfully ran all of the benchmark problems. Aside from a minor problem with the SYNTH3—a message stating "function too large for post-optimizer"—this program and the others executed correctly. It also posted some of the best execution times for 8087 configuration. This version of Microsoft FORTRAN is certainly vastly improved over its previous incarnation.

Prospero Software. Pro FORTRAN-77 is a British import. Its documentation is clear and compact, and the disk files are supplied with a checksum to verify the integrity of the files: the compiler checksums itself when invoked, and a utility to check other files in the system is supplied. The package consists of the compiler, libraries, a linker, a librarian program, a compiler configuration utility, and a symbolic debugger. The compiler is of a two-pass design, with 14 compile-time options to govern the production of additional outputs, the level of checking incorporated into the target machine, and memory model used. A configuration utility permits the definition of the default for each option. In an interesting twist, Prospero provides a source-code cross-reference utility as a stand-alone sample program on diskette rather than as a compiler option.

Both 8087 and non-8087 runtime libraries are provided. Although IEEE standard floating-point formats are used in both libraries, the non-8087 versions turned in significantly less accurate results that the 8087 version. This is the reason the non-8087 library is classified as alternate math in table 1.

The Prospero linker has an option to use only those runtime library routines that are actually required by the

object file. As a result, the executable code produced is very compact. It should be noted, however, that Pro FORTRAN-77 may use unorthodox techniques to achieve compact executable files. An examination of the linked file size for the benchmark BIGARRAY suggests that data initialization has been deferred from load time to execution; that is, it appears that a data initialization loop has been substituted for the DATA statement. An overlay option for the linker is also available, and no source code modification is required for its use. The symbolic debugger uses information optionally generated by the compiler in order to allow the user to monitor program execution.

Pro FORTRAN-77 is an update of the company's previous offering, Pro FORTRAN-66. This newer version produces very fast executable code for the non-8087 configuration. Pro FORTRAN-77 was, however, unable to compile SYNTH3. The reported error, at line 1405, was "Compiler stack size insufficient." For users tempted to tinker with the compiler so that it will handle larger source code files, a review of the license agreement certainly is in order. It states that "The User is warned that the Software may include a mechanism which will destroy its logic if an attempt is made to tamper with it and the Licensor accepts no responsibility if such a mechanism is activated." Although the copyright and indemnity sections are similar, it appears that checksum provisions were inadvertently left off of the license agreement.

Ryan-McFarland Corporation. RM/FORTRAN is written by Ryan-McFarland Corporation and is currently being sold by that company's distributors as well as by IBM Corporation. The IBM version, IBM PC Professional FORTRAN 1.0, was reviewed in October 1985. That product was actually RM/FORTRAN version 1.1 under the IBM label. The current version (4.1) is reviewed here.

RM/FORTRAN continues to be a relatively conservative implementation of the full language standard. Revisions since the previous review include the addition of a non-8087 library and a COMPLEX*16 data type. The compiler supports extensive compiler optimization, error diagnostics, and interactive debugging facilities. It is packaged with the Phoenix Software Associates Plink86 overlay linker and PLIB86 object file manager, and includes a compression utility for executable files. It includes an option to produce a source-code cross-reference listing and 80186/286-specific code. RM/FORTRAN was the first microcomputer FORTRAN-77 compiler to be certified by the GSA.

This compiler's performance in the benchmarks was average. Its execution times for the smaller programs were relatively fast, but like most of the other compilers, it was unable to handle SYNTH3. Perhaps the only noteworthy exception to an otherwise adequate performance for RM/FORTRAN was an astounding 28 minutes to compile 22 lines of code in the BIGARRAY problem. The compiler obviously was struggling with the DATA statement, which (as mentioned previously) technically could be replaced with several DO loops or other language constructs. In this particular case, however, patience was rewarded. The program was compiled successfully and it went on to turn in the fastest 8087 execution time for the problem (a record it shared with Microsoft FORTRAN).

RM/FORTRAN's extensions to the standard facilitate program transfer to other computers. It is thus a leader in the area of portability.

Finally, the product's manual includes many comparisons between RM/FORTRAN and some mainframe FORTRAN compilers. Extensions to the FORTRAN-77 standard have been included to facilitate program transfer from other computers. RM/FORTRAN should be a serious consideration for users concerned with portability.

WATCOM Products, Inc. WATFOR-77 is based on the WATFOR and WATFIV mainframe FORTRAN compilers from the University of Waterloo in Ontario, Canada. This family of compilers enjoys a widespread reputation for its excellent user interface and error diagnostics. WATFOR-77 also offers a number of program structure control elements, such as the SELECT and END SELECT statements, that are expected to be part of the FORTRAN-8x standard. For those interested in following the evolving FORTRAN language, this compiler is clearly the number one choice.

With the package, WATCOM supplies a general-purpose text editor, an intrinsic linker, and runtime debugger. The WATCOM Graphics Kernel System (GKS), a package that provides software for

creating, storing, and manipulating graphical images in conformance with the GKS (ISO 7492-1985) graphics standard, is included with WATFOR-77.

This product does use a type of copy protection. A nine-digit licensing agreement number is encoded on the program diskette of singly purchased copies. This number is entered at installation time by the user. Copies of the compiler that have been purchased under a site licensing agreement display a message indicating the expiration date of the agreement each time they are invoked. Site licensing agreements usually must be renewed yearly; however, users are permitted to make backup copies of either a singly purchased compiler or the site-licensed product.

Because the WATFOR-77 compiler is configured to immediately execute source code that has been compiled without error, separate compilers are supplied for machines with or without an 8087. As shown in table 4, this compiler was the only one to detect all errors in BIGERROR, but WATFOR-77 did take an inordinate number of compilation passes (10) to accomplish the complete debugging. Support of the option to force explicit declaration of all variables (IMPLICIT NONE) would have been most helpful in debugging the sample problem used here.

WATFOR-77 successfully compiled and executed all of the benchmarks except SYNTH3. Although the executable files generated are quite large, they are surprisingly fast. This is particularly true for non-8087 configurations. Along with its other good points, this compiler certainly is one of the easiest to use.

A FORMIDABLE FIELD

This field offers no single best choice for a FORTRAN compiler. Each has its merits. DRI FORTRAN-77 offers data types most closely resembling those used on the 8087. Lahey's F77L handled most of the benchmark problems, offers a variety of language extensions, and has very little restriction on the distribution of runtime files. Microsoft's revised FORTRAN ran all of the benchmarks, offers a superlative debugging capability, and produced the fastest 8087 execution times. Prospero Software's Pro FORTRAN-77 produced the fastest non-8087 execution times. Ryan-McFarland's RM/FORTRAN offers absolute compatibility with IBM Professional FORTRAN and is strong in portability. WATCOM's WATFOR-77 provides the best syntax analysis and is easy to use. Finally, Ellis Computing's Utah FORTRAN offers the lowest price by far.

The serious FORTRAN programmer probably will want to start with either the Microsoft or Lahey compiler. The casual user may wish to consider one of the easy-to-use imports: Pro FORTRAN-77 or WATFOR-77. Certainly, this field offers a range of compilers, one of which will fit any situation.

Digital Research, Inc.
Distributor: Alexander & Lord
P.O. Box 2110
Carmel Valley, CA 93924
408/659-2203
DRI FORTRAN-77 4.1: $350.00
CIRCLE 344 ON READER SERVICE CARD

Ellis Computing, Inc.
5655 Riggins Court, Suite 10
Reno, NV 89502
702/827-3030
Utah FORTRAN 1.0(4): $39.95
CIRCLE 345 ON READER SERVICE CARD

Lahey Computer Systems, Inc.
P.O. Box 6091
Incline Village, NV 89450-6091
702/831-2500
Lahey F77L FORTRAN 2.2: $477.00
CIRCLE 346 ON READER SERVICE CARD

Microsoft Corporation
P.O. Box 97017
Redmond, WA 98073-9717
800/426-9400; 206/882-8080
Microsoft FORTRAN 4.00A: $450.00
CIRCLE 347 ON READER SERVICE CARD

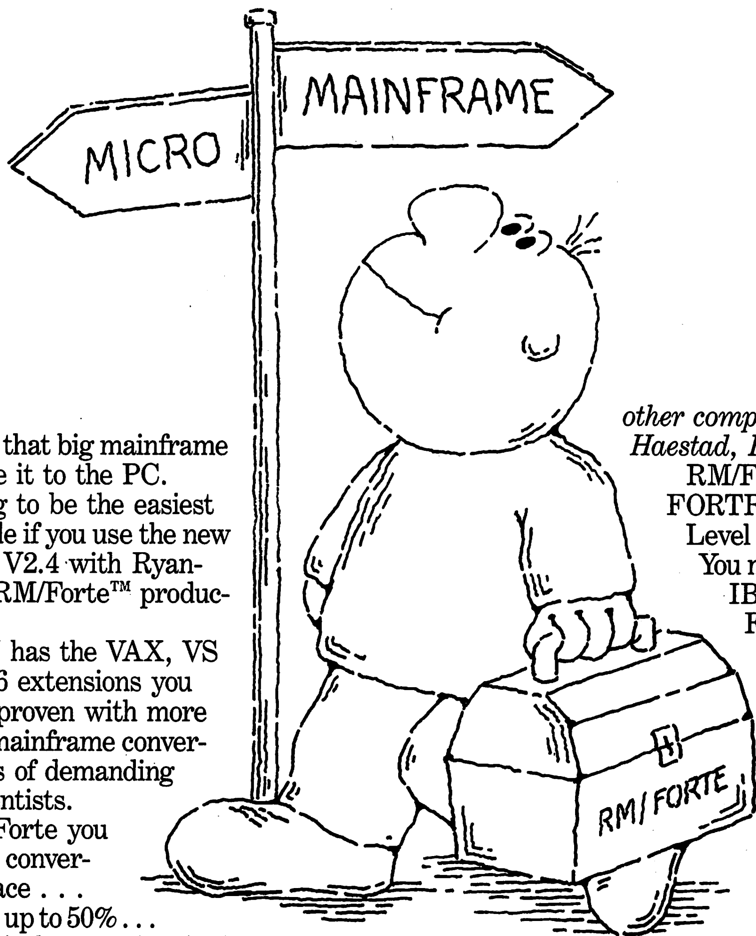
Prospero Software Limited
U.S. Distributor: Software Consulting Services
3162 Bath Pike
Nazareth, PA 18064
215/837-8484
Pro FORTRAN-77 1.141: $149.00
CIRCLE 348 ON READER SERVICE CARD

Ryan-McFarland Corporation
609 Deep Valley Drive
Rolling Hills Estates, CA 90274
213/541-4828
RM/FORTRAN 2.11: $595.00
CIRCLE 349 ON READER SERVICE CARD

WATCOM Products Inc.
415 Phillip Street
Waterloo, Ontario, Canada N2L 3X2
519/886-3700
WATFOR-77 1.4: $375.00
CIRCLE 350 ON READER SERVICE CARD

John Voglewede is an engineer with the U.S. Nuclear Regulatory Commission. He holds degrees in physics, computer science, and mechanical engineering. He has worked with FORTRAN for 20 years.

FORTRANS-MIGRATION.



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LISTING 1: PERFORM.F77

```
C     PERFORM - A FORTRAN Benchmark
      INTEGER I
      DOUBLE PRECISION A, B, C, D
C
      WRITE(6,1000)
      D = 0.0
      DO 100 I = 1, 10000
C
C       Implicit conversion.  Use of intrinsic function FLOAT
C       available in ANSI X3.9-1978 but not recommended.
        A=I
C
C       Generic names used for intrinsic functions.  Function
C       type is automatically set to that of the argument.
C       Note that TAN(X) = SIN(X)/COS(X)
C
        B = ATAN(LOG(A))
        C = A - EXP(SIN(B)/COS(B))
        D = D + C * C
  100 CONTINUE
      WRITE(6,1010) D
 1000 FORMAT(2X,'Double Precision Benchmark')
 1010 FORMAT(2X,'ERROR = ',1E9.3)
      END
```

LISTING 2: MINIMUM.F77

```
END
```

LISTING 3: SYNTH1.F77

```
C     SYNTHETIC FORTRAN SOURCE CODE
C
      IMPLICIT REAL (A-D)
      DATA A000/1.0/,B000/2.0/,C000/3.0/,D000/4.0/
      A001 = C000 - B000
      B001 = D000 / B000
      C001 = A000 + B000
      D001 = B000 * B000
      A002 = C001 - B001
      B002 = D001 / B001
      C002 = A001 + B001
      D002 = B001 * B001
      A003 = C002 - B002
      B003 = D002 / B002
      C003 = A002 + B002
      D003 = B002 * B002
      A004 = C003 - B003
      B004 = D003 / B003
      C004 = A003 + B003
      D004 = B003 * B003
      A005 = C004 - B004
      B005 = D004 / B004
      C005 = A004 + B004
      D005 = B004 * B004
      WRITE(*,1000) A005, B005, C005, D005
 1000 FORMAT(4F10.1)
      END
```

LISTING 4: ITERATE.F77

```
C     ITERATIVE FORTRAN SOURCE CODE
C
      INTEGER I,  J
      REAL    A0, B0, C0, D0
      REAL    A1, B1, C1, D1
C
      DATA A0/1.0/, B0/2.0/, C0/3.0/, D0/4.0/
C
      DO 10 I=1,1000
        DO 10 J=1,1000
          A1 = C0 - B0
          B1 = D0 / B0
          C1 = A0 + B0
          D1 = B0 * B0
          A0 = C1 - B1
          B0 = D1 / B1
          C0 = A1 + B1
```

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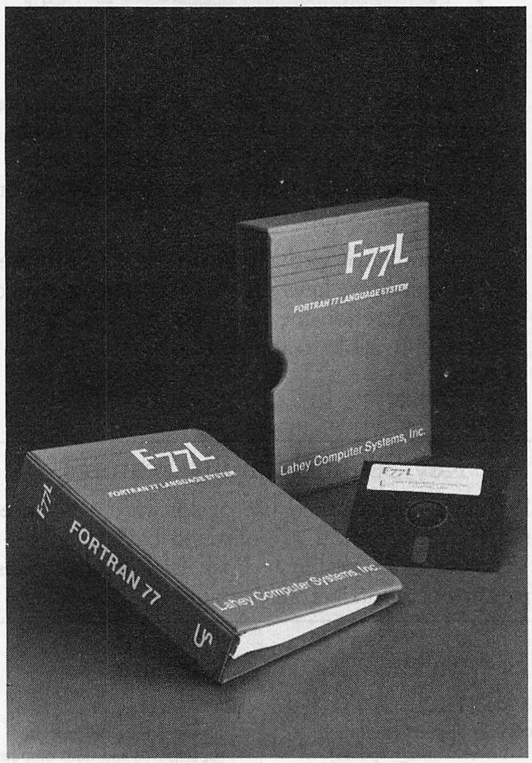

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```
      DO = B1 * B1
   10 CONTINUE
C
      WRITE(*,1000) A1, B1, C1, D1
 1000 FORMAT(4F10.1)
      END
```

LISTING 5: BIGARRAY.F77

```
C     PROGRAM WITH A LARGE ARRAY
C
      INTEGER I, J
      REAL MATRIX, SUM
      DIMENSION MATRIX(200,200)
C
C     MATRIX IS A 200 X 200 = 40000 ELEMENT ARRAY
C     OR 160 KILOBYTES AT 4 BYTES/ELEMENT
C
      DATA MATRIX/10000*1.0,10000*2.0,10000*3.0,10000*4.0/
C
C     Calculate the sum of all elements
C
      SUM = 0.0
      DO 10 J=1,200
        DO 10 I=1,200
          SUM = SUM + MATRIX(I,J)
   10 CONTINUE
C
      WRITE(*,1000) SUM
 1000 FORMAT(2X,'SUM = ',1F9.1)
      END
```

LISTING 6: BIGERROR.F77

```
      PROGRAM WITH  LARGE ERRORS
C
      INTEGER  SUM
      REAL MATRIX  SUM
      DIMENSION MATRIX 200,200)
C
      MATRIX IS A 200 X 200 = 40000 ELEMENT ARRAY
C     OR 160 KILOBYTES AT 4 BYTES/ELEMENT
C
      DATA MATRIX/20000*1.0,20000*2.0,20000*3.0,20000*4.0/
C
C     Calculate the sum of all elements
C
C     SUM = 0.0
      DO 10 J=1,300
        DO 10 I=1 200
        I = SUM + MATRIX(I,J)
   11 CONTINUE
C
      WRITE(*,1000) SUN
 1001 FORMAT(2X,'SUM = ',1F9.1)
C     END
```

COMMENTS ON BIGERROR

1	PROGRAM STATEMENT WITH MULTIPLE NAMES/PROGRAM NAME TOO LONG
2	
3	VARIABLE SUM DEFINED AS BOTH INTEGER AND REAL
4	DELIMITING COMMA MISSING BETWEEN VARIABLES
5	OPEN PARENTHESIS MISSING IN DIMENSION STATEMENT
6	
7	MISSING "C" IN COLUMN ONE OF THIS COMMENT LINE
8	
9	
10	TOO MANY VALUES IN DATA STATEMENT
11	
12	
13	
14	COMMENT LINE - VARIABLE "SUM" IS NOW UNDEFINED
15	DO-LOOP INDEX LARGER THAN ARRAY SUBSCRIPT BOUNDS
16	MISSING COMMA DELIMITER IN DO-LOOP RANGE
17	DO-LOOP INDEX CHANGED WITHIN DO-LOOP
18	STATMENT LABEL IS INCORRECT - SHOULD BE "10"
19	
20	VARIABLE "SUM" MISSPELLED
21	FORMAT LABEL INCORRECT - SHOULD BE "1000"
22	COMMENT LINE - END STATEMENT NOW MISSING

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```
SQL:
SELECT *
FROM WORKONTAB, PROJECTS, EMPLOYEES-
WHERE WORKTONTAB.ENUM = EMPLOYEES.ENUM-
AND WORKONTAB.PNUM = PROJECTS.PNUM-
AND PROJNAME = 'ALPHA'

ZIM:
List all employees workon projects where
projname = 'Alpha'
```

A typical SQL command and the ZIM equivalent.

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Speed Infusion

Part 3

A third type of accelerator board for the PC replaces the 8088 microprocessor with an 80286 and adds either a full complement of memory or a high-speed cache.

TED MIRECKI

PHOTOGRAPH • MARC DAVID COHEN

Computer systems, like people, seem to grow slower with age. Although, by all objective measures, that five-year-old IBM PC still runs at the speed it did when first purchased, it does not seem to run as fast as it did when it was brand new. Did it really slow down, or does it just seem that way since the new 80386-based machines were brought in?

Two different approaches for making the PC run faster were covered in the first two installments of this series. "Speed Infusion, Part 1" (Ted Mirecki, February 1987, p. 126) covered Class I accelerators that speed up the original PC hardware with faster clock rates. The Class II accelerator boards, reviewed in "Speed Infusion, Part 2," (Ted Mirecki, April 1987, p. 66) replace the 8088 microprocessor with an 8086, which not only runs faster, but also does more work per unit of time.

The next step in escalating PC performance is the Class III accelerator board, containing an even more capable processor—the 80286. Eleven products of this type, divided into two categories based upon the amount of memory, are considered. Four *full-complement* boards are reviewed: the Applied Reasoning Corporation (ARC) PC-elevATor; Classic Technology, Inc. 286 SPEED PAK; Orchid Technology PCturbo 286e; and Seattle Telecom & Data, Inc. (STD) PC-286. Seven boards that use *cache* memory are compared: the MicroWay FastCACHE 286; Mountain Computer, Inc. RaceCard 286; Orchid Technology TinyTurbo 286; Personal Computer Support Group (PCSG) Breakthru 286; PC Technologies, Inc. (PCT) 286 Express; Sigma Designs TurboCache 286; and Victor Technologies, Inc. SpeedPac 286. The general characteristics of the boards are listed in table 1.

Speeding up a PC by the insertion of an 80286 is fundamentally different than merely increasing the clock rate or replacing the 8088 with an 8086. Those methods turn a slow PC into a not-so-slow PC, but it remains a PC nevertheless. On the other hand, the 80286 is the defining characteristic of the PC/AT.

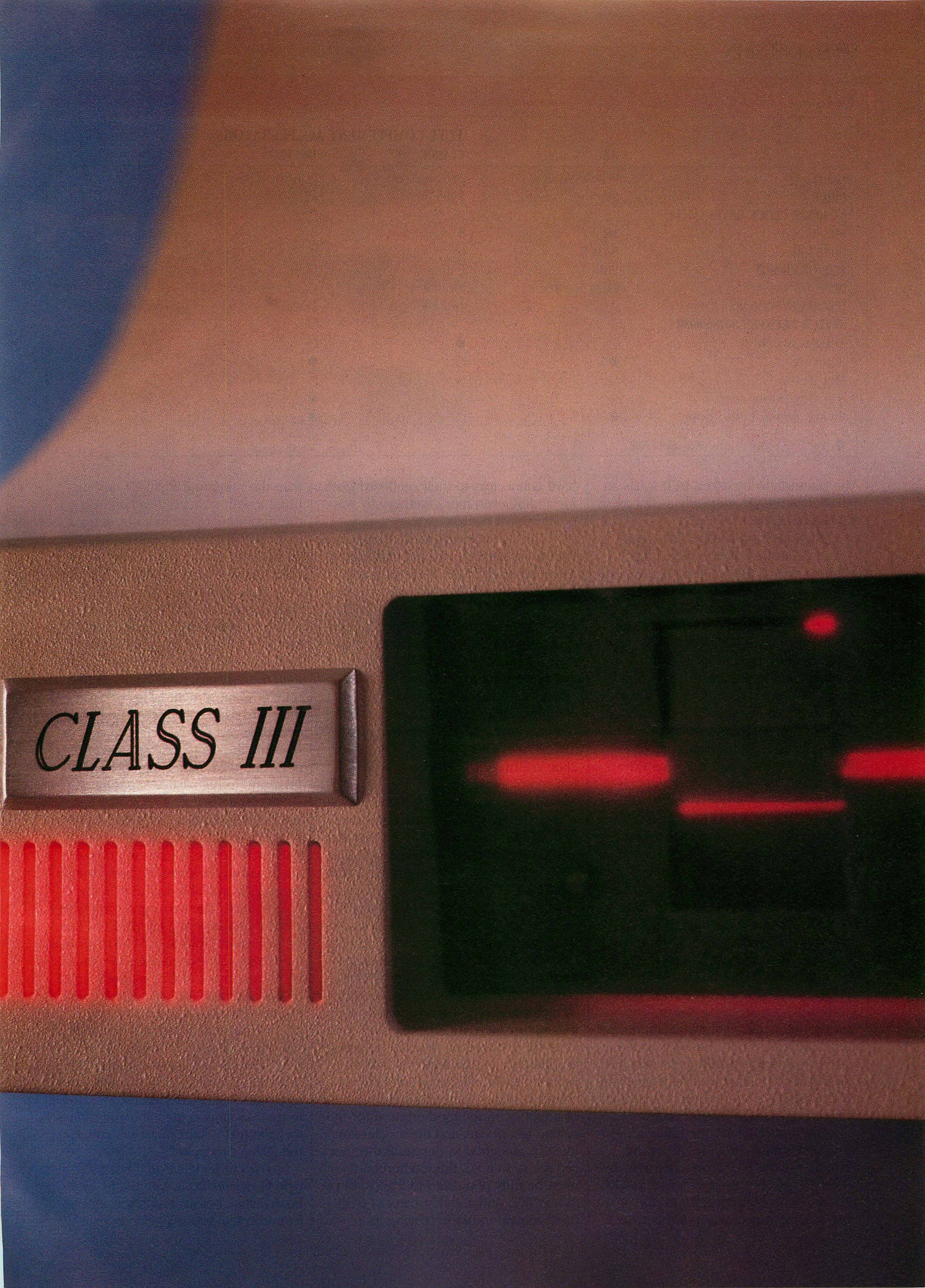
CLASS III

TABLE 1: *286 Accelerator Characteristics*

	FULL-COMPLEMENT ACCELERATORS			
	ARC	**CLASSIC**	**ORCHID**	**STD**
MODEL	PC-elevATor	286 SPEED PAK	PCturbo 286e	PC-286
PRICE	$995	$995	$1,195	$1,500
NOMINAL CLOCK RATES (MHz)				
80286 clock	10	8	8	12
80287 clock	5 or 8	6	8	8
SIZE OF BOARD	Full	Full	Full	Full
TYPE	Coprocessor	Emulator	Coprocessor	Emulator
ON-BOARD MEMORY (KB)	2,048	1,024	1,024	640
SWITCH BETWEEN 80286/8088				
Toggle switch	○	●	○	○
Software	●	○	●	○
Hot key	○	○	○	○
Switch without reset	○	○	●	N/A
Switch without cold boot	●	○	●	N/A

●=Yes ○=No N/A=Not applicable

The question to be asked is: if it has an 80286, is it an AT—not only as fast as an AT, but *really* an AT?

That question is especially pertinent now, in light of the recent announcement of IBM's Operating System/2 (OS/2), the long-awaited protected-mode operating system that will finally tap the full potential of the 80286 (see this month's Tech Releases, p. 32). This development makes it clear that the AT is not merely a faster PC, but is significantly different. The motivation for adding an 80286 accelerator to a PC, then, is not only raw speed, but also the tempting—though perhaps remote—possibility of running OS/2 on a PC equipped with such an accelerator.

COMPLEMENT VERSUS CACHE

The insertion of a foreign processor into a PC, even one as closely related as the 80286 is to the 8088, presents some compatibility problems. A significant advantage of the 80286 is its word-wide (16-bit) data transfers compared with the byte-wide (8-bit) transfers of the 8088. The PC data bus, however, is only one byte wide. Although the 80286 can perform byte-wide transfers, doing so wastes a large part of its power. The first problem, then, is how to interface the 80286 with the PC bus. Two main approaches to this problem are to provide a full complement of high-speed memory, or to provide only a small part of memory as a high-speed cache.

The first category, the full-complement accelerator, provides all of the memory for the 80286 on a separate 16-bit bus. Typically, this memory is 640KB and can be as high as 2MB on one board. Some accelerators of this type have connectors to their on-board bus for adding even more memory by way of additional boards.

The two methods used to integrate the 16-bit memory into the existing memory space of the 8088 splits full-complement accelerators into two categories. The first type, the *coprocessor* board, provides the 80286 with its own address space (distinct from that of the 8088), and usually leaves the 8088 in its socket on the motherboard. Such an accelerator is essentially a single-board computer that shares peripherals, but not memory, with the host system. The ARC PC-elevATor and Orchid PCturbo 286e are two examples of this type of full-complement board.

The second type of full-complement accelerator, the *emulator* board, provides up to 640KB of 16-bit memory in the original 8088 address space. The 8088 is either removed entirely, as with the STD PC-286, or switched into an inactive state when the 80286 is running, as on the Classic 286 SPEED PAK. In the latter case, the user can switch back to operate on the 8088. With emulator boards, memory on the original 8-bit bus becomes unused, and as much of it as possible should be removed from the system. Memory on expansion cards *must* be removed or disabled because the memory on the accelerator board replaces it. But the design of IBM machines requires some minimum amount of memory on the motherboard for the system to operate, and the accelerator must be designed to duplicate this, not replace it. In a PC, the motherboard must be fully populated to 256KB, but in a PC/XT, only the first bank of 64KB need remain in place. Leaving more than the minimum in an XT and disabling it with switches has no effect on the machine's operation, but doing so increases the system's power requirements because the chips remain powered and still draw current.

The second major category of 80286 accelerators is the caching board, which provides only a small portion of memory space as a high-speed cache. This approach is based on the premise that, in most programs, much of the time is spent in tight loops or accessing the same data. A significant increase in overall speed can be achieved by storing only the frequently accessed instructions and data, rather than the entire program, in high-speed memory.

Caching boards are smaller (usually half-length), simpler, and less expensive than full-complement boards. They may not even have an on-board clock to run the circuitry, using the timing signals available in the PC's bus slots instead. The two signals available are the oscillator at 14.3 MHz and the PC processor clock at 4.77 MHz. Unlike the 8086 processors covered in Part 2, an 80286 cannot obtain its clock signal by doubling the 4.77 MHz frequency because the 80286 operates at a frequency that is one-half the frequency of the signal on it clock input. For example, the 8-MHz processor in the AT has a 16-MHz signal feeding into it. Therefore, the only useful frequency available in the bus slots is the 14.3-MHz oscillator, and this results in a clock rate for the 80286 processorof 7.2 MHz.

The clock signal on a board of this type is *synchronous* with the motherboard clock because both are generated from the same source—the oscillator.

CACHE-MEMORY ACCELERATORS

MICROWAY	MOUNTAIN	ORCHID	PCSG	PCT	SIGMA	VICTOR
FastCACHE 286 $599	RaceCard-286 $595	TinyTurbo 286 $695	Breakthru 286 $395	286 Express Card $595	TurboCache 286 $649	SpeedPac 286 $349
12	8	8	12	8	10	8
6 or 12	6 or 8	8	6 or 12	6 or 8	10	6 or 8
Half	Half	Half	Half	Half	Full	Half
Asynch.	Synch.	Synch.	Asynch.	Synch.	Asynch.	Synch.
8	8	8	16	8	16	8
●	○	●	○	●	●	○
○	○	○	○	○	●	○
○	○	○	○	○	●	○
○	N/A	○	N/A	○	●	N/A
○	N/A	●	N/A	●	●	N/A

Full-complement boards have 640KB or more of RAM on a 16-bit bus; caching boards have 8KB to 16KB of high-speed memory.

Examples of this type of caching board are the Mountain RaceCard 286, the Orchid TinyTurbo, the PCT 286 Express, and the Victor SpeedPac 286. These boards are rapidly becoming commodity items (in fact, the Mountain and Victor products are the identical item sold under different labels), and their performance is virtually identical.

Higher clock rates on the accelerator can be achieved by *asynchronous* means—that is, by providing an independent on-board clock. Three of the high-speed cache boards are of this type: the MicroWay FastCACHE 286, PCSG Breakthru 286, and Sigma TurboCache 286. The pay-off for the cost and complexity of an asynchronous design is a higher processor speed, but there is also a reduction in bus performance.

BUS TRANSFER

The maximum speed of transferring information between the processor and the bus is called the *bus bandwidth*. This speed depends on three variables: the clock rate, the number of clock cycles per bus access cycle, and the number of bits transferred on each bus cycle. The 8088 microprocessor in the PC takes four clock cycles per bus cycle, while the 80286 needs a minimum of two clock cycles. To synchronize with slower memory and I/O devices, the processor monitors a "not ready" signal that is raised by each addressed device for the duration of the data transfer. Processing cannot continue until the ready line indicates that the transfer is complete, and, if this transfer takes longer than two clock cycles, the processor remains idle for one or more clock cycles called wait states.

When the processor and bus are designed as a unit (as in the case of the AT, full-complement accelerators, and cache memory), the bus bandwidth can be matched to the capabilities of the processor by the choice of memory components. The IBM AT, Classic 286 SPEED PAK, and STD PC-286 opt for more readily available slower (and cheaper) memory, matching it to the processor's clock speed by the insertion of one wait state per cycle. The memory on the ARC PC-elevATor and Orchid PCturbo 286e, as well as all the cache memories, are implemented with chips capable of data transfers with zero wait states.

The situation is different when a processor must access data through an existing bus of fixed bandwidth. This is the case when a caching board experiences a cache miss and must fetch data from main system memory. The maximum data transfer rate then is the same as for the 8088 at the original clock rate of 4.77 MHz, as demonstrated by all the reviewed caching boards that have synchronous 7.2 MHz clocks.

The maximum bandwidth of the original PC bus can be achieved only if the processor synchronizes bus requests with clock cycles on the bus. If the processor clock and bus clock run synchronously, transfer requests from the processor occur at the beginnings of a bus cycle. With an asynchronous processor, however, transfer requests can occur in the middle of clock cycles on the bus. The bus needs 4 integral clock cycles per transfer, but if the request comes halfway through a clock cycle on the bus, then the transfer will not be complete until 4½ clock cycles later. In the worst case, a request can occur just after the start of a clock cycle on the bus, and the transfer will then take almost 5 clock cycles. Boards with asynchronous clocks must allow for this worst-case scenario. Thus, their bus cycle is fixed at five bus clocks instead of four, resulting in a bandwidth that is 80 percent of the original. This is the trade-off for the higher processor clock speed that is attainable with an asynchronous clock, but, judging by the performance in real-world applications, the sacrifice is worthwhile.

Whereas the problem of matching a high-speed processor to low-speed memory can be solved either by replacing the memory or by caching it, the problem remains of other activity on the PC bus, namely to the I/O ports. Replacing the I/O devices is not practical, because that would be as expensive as replacing the whole system. For many devices, however, the speed of the device itself is more limiting than the speed of the bus. Printers and serial ports run at their own rates governed by their physical limitations, and feeding data to them faster just results in more idle time between transfers.

Other peripherals, specifically the hard disk, are limited by the rate of data transfer. In addition, the physical speed of the disk itself, not only the rate of data coming to it, is an issue. In disk-intensive operations, the speed advantage an AT has over a PC is not primarily a function of the 80286, but of the disk drive. In such cases the effect of an accelerator card is minimal.

The bus bandwidth is not the only compatibility issue. Because the presence of an 80286 microprocessor is the defining characteristic of AT-class sys-

PHOTO 1: *ARC PC-elevATor*

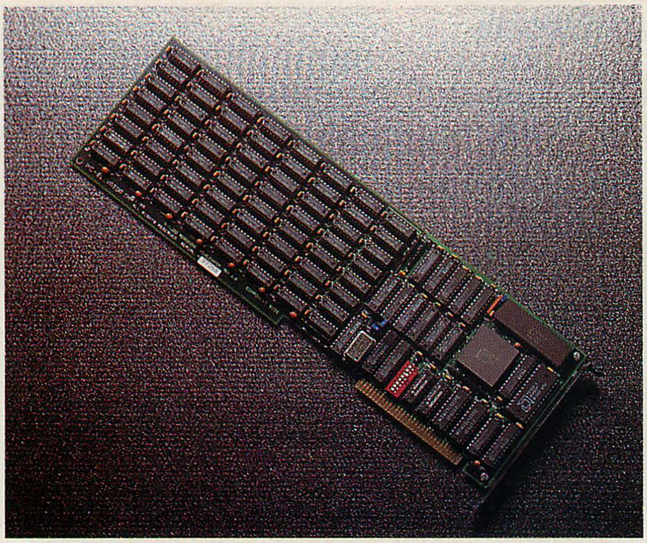

PHOTO 2: *Classic 286 SPEED PAK*

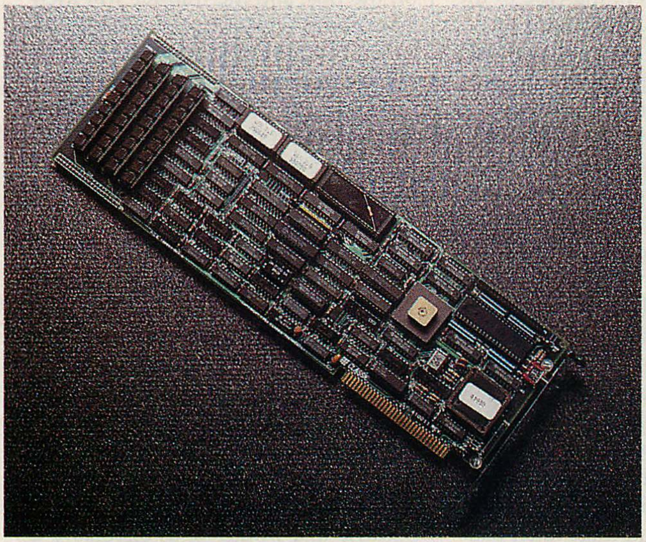

PHOTO 3: *Orchid PCturbo 286e*

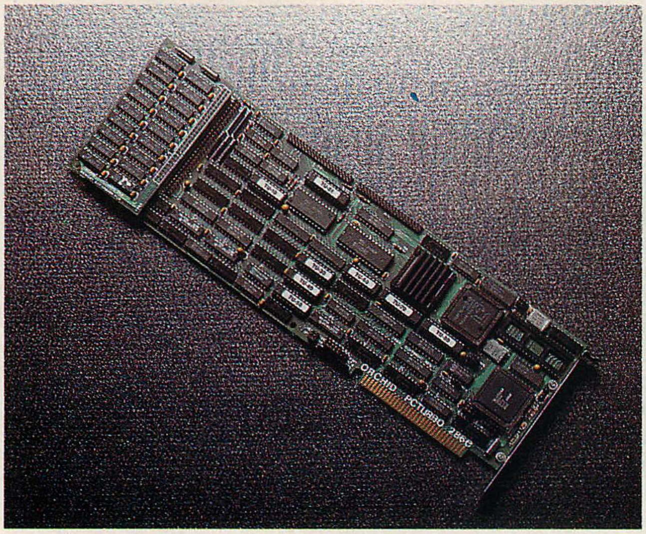

PHOTO 4: *STD PC-286*

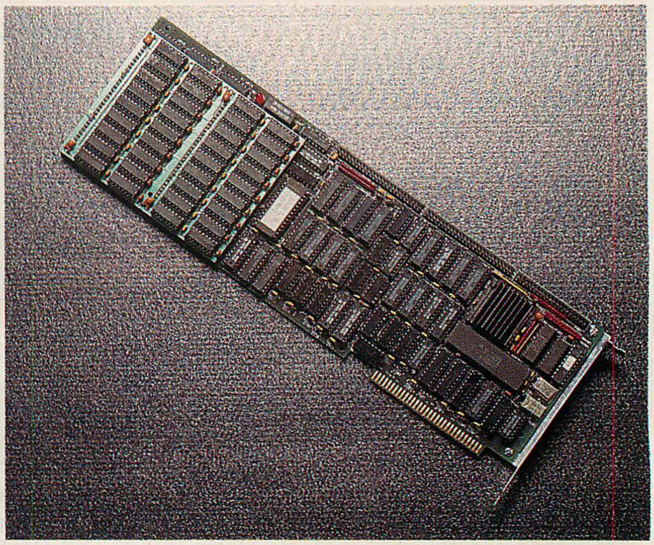

PHOTO 5: *MicroWay FastCACHE 286*

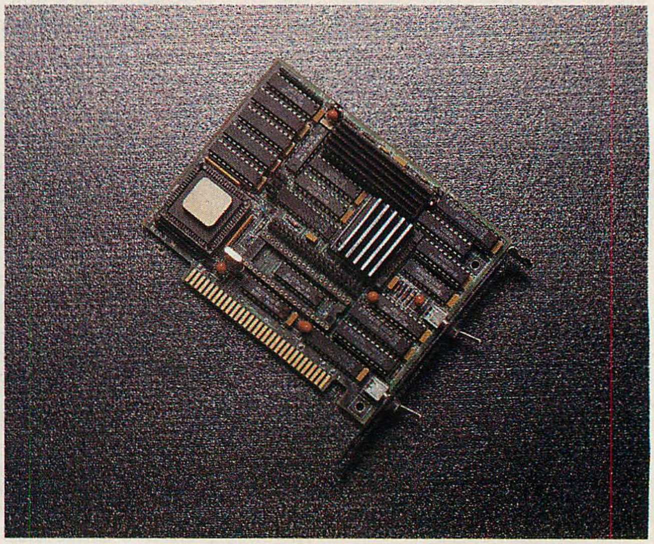

PHOTO 6: *Mountain RaceCard 286*

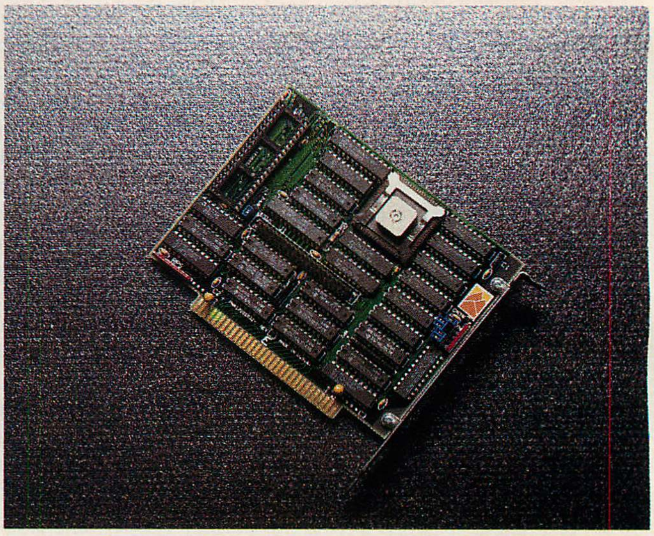

PHOTO 7: *Orchid TinyTurbo*

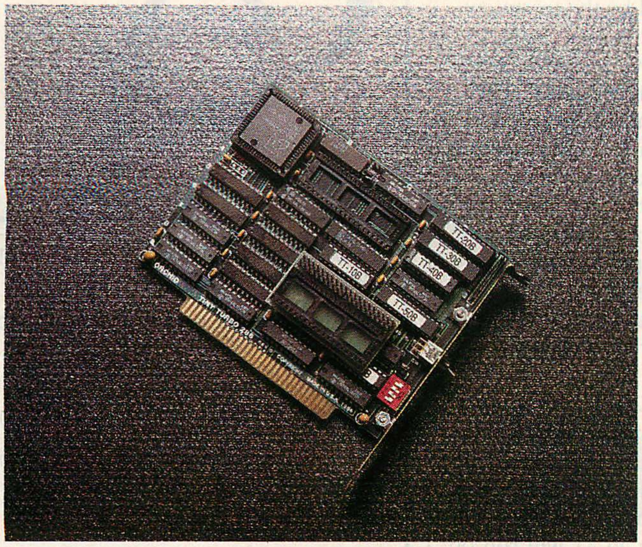

PHOTO 8: *PCSG Breakthru 286*

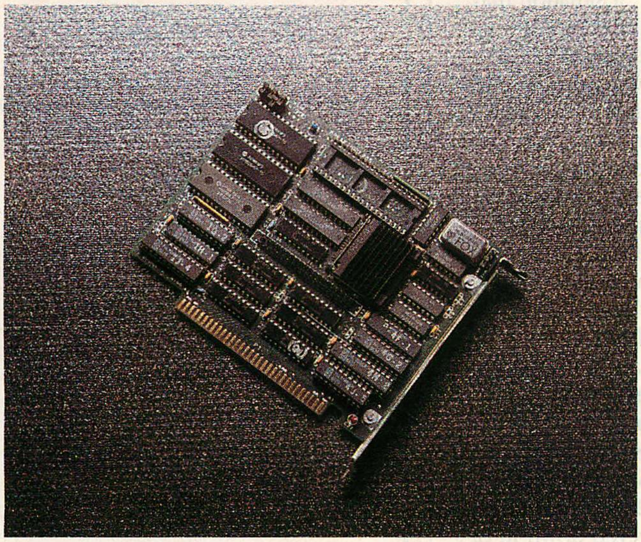

PHOTO 9: *PCT 286 Express*

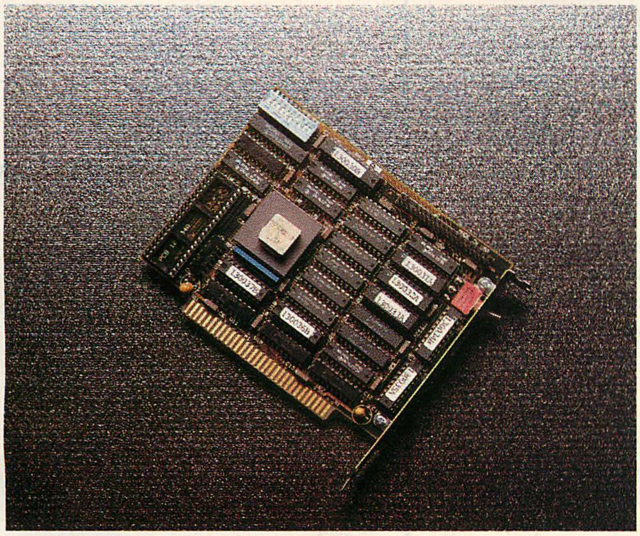

PHOTO 10: *Sigma TurboCache 286*

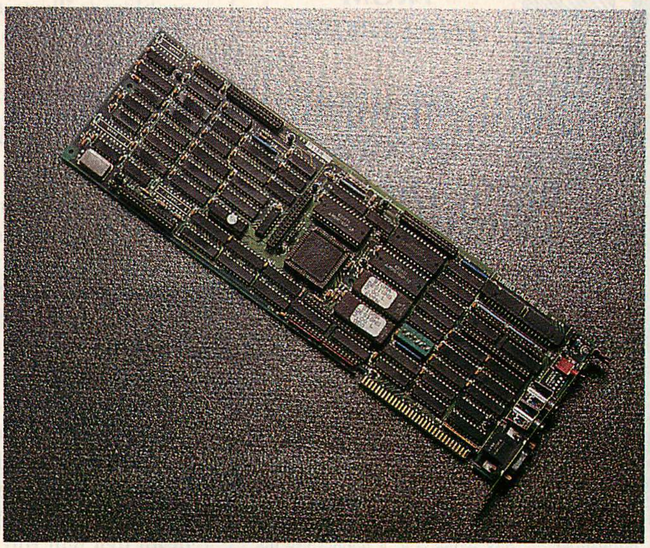

PHOTO 11: *Victor SpeedPac 286*

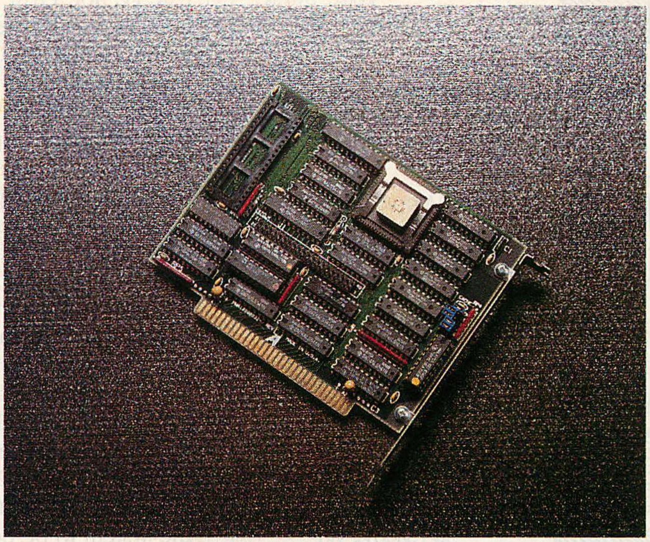

Photo 1: The ARC PC-elevATor is a full-complement coprocessor board with 2MB of RAM on a 16-bit local bus.

Photo 2: The Classic 286 SPEED PAK is an emulator board that places 1MB of RAM in the 8088 address space.

Photo 3: Orchid's PCturbo 286e is a coprocessor with 1MB RAM; it leaves the PC's original 8088 fully operational.

Photo 4: The STD PC-286, an emulator with 640KB of RAM, has the fastest clock rate of all the boards tested.

Photo 5: MicroWay's FastCACHE 286 has switches that control the speed at boot-up and turn caching on and off.

Photo 6: The Mountain RaceCard 286 is a caching accelerator with a synchronous clock that runs at 7.2 MHz.

Photo 7: Orchid's TinyTurbo 286 has a switch that determines which processor is in control at boot-up.

Photo 8: The PCSG Breakthru 286 achieved the best performance results of the caching boards tested.

Photo 9: The PCT 286 Express has the ability to switch between the 80286 and 8088 without requiring a cold reboot.

Photo 10: Sigma's TurboCache 286 allows an EGA or 640-by-400-pixel resolution color video adapter to be added.

Photo 11: Victor's SpeedPac 286 is identical in performance and appearance to the Mountain RaceCard 286.

tems, should a PC with that processor behave more like an AT or a PC? The problem is illustrated by the treatment of the error interrupt from a numeric coprocessor. In the PC, an 8087 coprocessor signals exceptions on the NMI (nonmaskable interrupt) line, whereas in an AT, the 80287 interrupts on IRQ 2, which in the PC is marked "reserved." The MicroWay FastCACHE 286 board passes this decision on to the user, who can choose either implementation by means of a jumper setting.

Also to be considered when judging 80286 accelerators is whether they possess the ability to switch between operations on the 80286 and the original 8088. This is becoming less of an issue as software is increasingly being designed to be independent of the processor clock speed. In most cases, any program that will run on an AT will run on these accelerators. Still, because a PC with an 80286 accelerator is neither a true PC nor a true AT, a situation may arise in which reverting to true PC operation becomes necessary. The higher the clock speed of the accelerator, the greater the likelihood of encountering some program or peripheral that cannot support it, thus requiring switching back to a slower speed. Of those reviewed, one full-complement board (the STD PC-286) and three caching boards (the Mountain RaceCard, PCSG Breakthru, and Victor SpeedPac 286) do not provide this capability.

Of the boards that do provide the capability to switch processors, all except the Orchid PCTurbo 286e and the Sigma TurboCache 286 require a system reset. The Classic 286 SPEED PAK and MicroWay FastCACHE 286 even require the system to be powered down in order to make the switch.

Given all the potential problems of grafting a new processor into an old system, it is surprising that these products work at all. But they do work, and quite well at that. Overall, there were fewer problems with these boards than with the seemingly simpler 8086 accelerators reviewed in part 2.

STEP BY STEP

The installation procedure for most of these boards is very similar. The most common procedure is described here; any differences are noted in the individual product descriptions below.

The first step is to set any jumpers or switches on the accelerator board. Most allow the setting of the clock speed for various models of the 80287 coprocessor, and some caching boards need to be set for the total amount of

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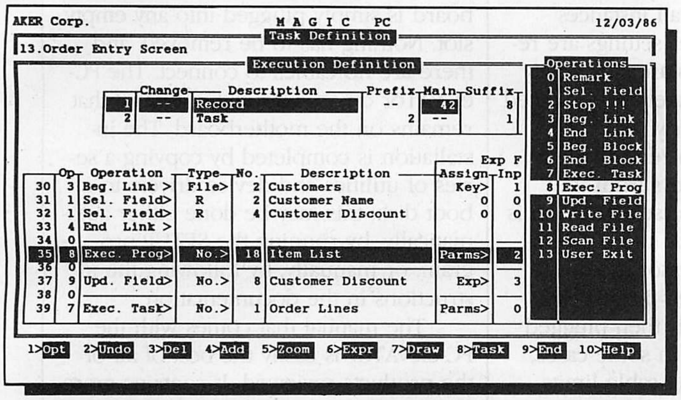

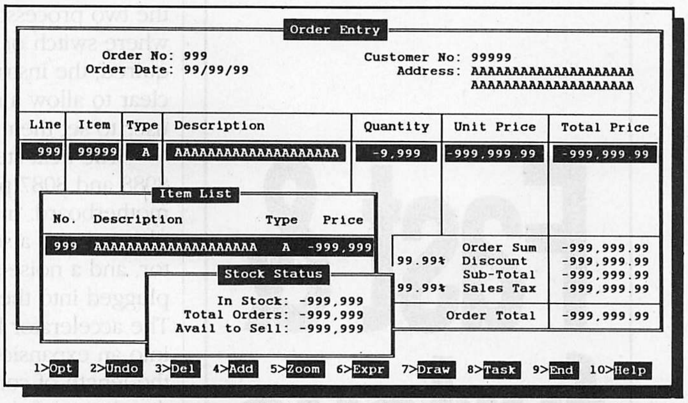

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memory in the system. Another common setting, especially on coprocessor boards, is to determine the address of I/O ports for communication between the two processors. In all instances where switch or jumper settings are required, the instructions are sufficiently clear to allow a moderately experienced user to set them properly.

The next step is to remove the 8088 and 8087 processors from the motherboard. In most cases, the 8088 is plugged into a socket on the accelerator, and a noise-suppressor module is plugged into the vacated 8087 socket. The accelerator board is then plugged into an expansion slot; in some cases, the length of connecting cable limits the choice of slots to one of the two slots next to the 8088 socket.

Finally, a ribbon cable is connected between a double-row pin header on the accelerator and the motherboard socket that contained the 8088 processor. The instructions for this step are typically harder to follow because the cables are not usually keyed and the plugs that fit into the integrated circuit (IC) socket are not well marked. In some cases, contrary to convention, the striped edge of the ribbon cable is not connected to pin 1 of the socket. Those manuals that use illustrations rather than descriptions of the process are much easier to follow.

Given all the potential problems of grafting a new processor into an old system, it is surprising that these products work at all.

FULL-COMPLEMENT BOARDS

Class III accelerators in this category use a full complement of memory for the 80286 processor on a separate 16-bit bus. Providing this extra amount of memory, which can be as much as 2MB on one board, is more expensive.

Applied Reasoning Corporation (ARC). Available in versions running at 8, 10, or 12.5 MHz, the PC-elevATor is a true coprocessor board with 2MB of RAM. It can be set to run an 80287 at 4.77 MHz (the speed of the 8088 on the motherboard), 7.2 MHz (one-and-a-half times the speed of the 8088), or at two-thirds the speed of the 80286. The unit tested was a 10-MHz model with the 80287 running at 7.2 MHz.

Installation is simpler than the standard procedure outlined above: the board is simply plugged into any empty slot. Nothing has to be removed, and there are no cables to connect. The PC-elevATor can coexist with the 8088 that remains on the motherboard. The installation is completed by copying a series of utilities and device drivers to a boot disk; this may be done either automatically, by running the SETUP program, or manually, by following the instructions in the documentation.

The manual that comes with the PC-elevATor is easily the best of all of the products reviewed. It contains more than 90 pages, including a useful table of contents and comprehensive index. Chapters cover hardware and software installation, operation, troubleshooting, and technical information on the board and the utility programs. The documentation does justice to a complex and well-designed product.

Once installed and running, the PC-elevATor is for all practical purposes a second computer inside the PC. It has its own memory space, all of it accessed via a 16-bit bus with zero wait states. The memory above 640KB is treated as 80286 extended memory for protected-mode access only. It can be used to install VDISK, or, by means of a supplied utility, to emulate expanded memory according to the Lotus/Intel/Microsoft expanded memory specification (LIM EMS). The original system's memory, including any LIM EMS or AST/Quadram/Ashton-Tate Enhanced EMS (AQA EEMS), can be left in place. Each processor has access only to its own complement of expanded memory.

In operation, a system with a PC-elevATor looks and feels impressively fast. Writing to the screen is especially rapid, but somewhat disconcerting because scrolling is very jerky.

Booting-up the system can be done on either processor, depending upon the contents of the AUTOEXEC.BAT and CONFIG.SYS files. Switching between the two is performed by running utility programs at the DOS level; ARC calls it going "upstairs" to the 80286 or "downstairs" to the 8088. The state of the downstairs machine is unchanged upon returning from upstairs, and even RAM disks in both conventional and expanded memory remain intact. But each trip upstairs reboots the 80286. Before being taken downstairs, the user is warned that the contents of upstairs memory will not be recovered, and is given a chance to cancel the request. In

addition, the user cannot leave a program executing on one processor after switching to another.

The performance of the PC-elevATor is near the top; the only board to exceed it (the STD PC-286) runs at a 25-percent faster clock speed. The inability to keep the contents of 80286 memory when switching processors is the PC-elevATor's only drawback because the Orchid PCturbo 286e shows that the contents of the 80286 memory can be maintained after switching.

Classic Technology, Inc. The 286 SPEED PAK is an emulator board equipped with 1MB of RAM. It comes in versions running at 8 or 10 MHz, with the single-speed 80287 clock running at two-thirds of that rate. The 8-MHz unit is the version reviewed here.

With the exception that any conventional memory (below 640KB) on expansion boards must be removed or disabled, installing the 286 SPEED PAK follows the standard example. A potential for error in the installation process exists because the 8088 chip mounts on the board facing in the opposite direction from all of the other chips; the socket is plainly marked, however, and the manual gives clear instructions. The entire installation process is described thoroughly, and, in general, the documentation is quite good.

The system boots up on the 8088 or the 80286, depending on the position of a toggle switch on the rear bracket. According to the documentation, this switch is designed to be used only when the system is powered down; switching it while the system is running may cause a reset, or, more likely, may cause it to lock up.

Software is provided for a print spooler and a RAM disk. The latter is a terminate-and-stay-resident (TSR) program, not a device driver, and it emulates a standard diskette, so it's capacity is limited to 360KB.

Another feature is the connector to the 16-bit, on-board memory bus. This allows connecting additional extended memory on other expansion cards (from the same company only), up to the processor's limit of 16MB.

Although it is a well-designed and reliable board, the Classic 286 SPEED PAK provides lackluster performance due to its modest clock rates and insertion of a wait state into memory accesses. The results obtained with the reviewed 8-MHz board are not significantly better than those obtained with the faster caching boards. The 10-MHz version would, no doubt, provide more interesting performance results.

Orchid Technology. This company manufactures both a full-complement board and a caching board. The PCturbo 286e is the full-complement coprocessor board. Although it comes with 1MB of RAM on board, only 704KB of this is usable (640KB with an EGA) because the rest is taken up by system overhead. As an option, an additional megabyte may be added as extended memory for access only in the protected mode of the 80286 or for use by RAM disks, such as VDISK included with DOS. The 80286 clock speed is 8 MHz, and the 80287 clock may be set by the user at either 4.77 or 8 MHz. Installation is simple, requiring no removal of any parts from the motherboard; all communications between the accelerator and the host system is made via the bus slot. A program is provided to set up the software automatically on a boot disk.

With the PCturbo 286e installed, the user definitely perceives a speed-up in operation. Screen updates are noticeably faster, and, unlike on the ARC PC-elevATor, scrolling is smooth. A significant amount of video "snow" is apparent on the screen, but an installation option can eliminate it at the expense of somewhat slower screen operations.

The Orchid PCturbo 286e even allows multiprocessing—that is, the simultaneous execution of programs on each processor.

The integration between the 80286 on the accelerator and the 8088 on the motherboard is better than with the PC-elevATor. Switching execution from one processor to another is performed by running programs at the DOS level. Unlike the PC-elevATor, the PCturbo 286e does not reboot the processor being switched to, so no data in memory are lost. Even the RAM drives that are set up on the 8088 machine (including any in EMS memory) are available to the program running on the 80286. More significantly, the user can bring up an application on each processor and switch between them. Because switching is done by DOS commands, the applications must allow shelling to the operating system or provide some other method of executing DOS programs. This process would be more convenient if Orchid supplied a resident utility that could switch from within programs in response to hot keys.

The PCturbo 286e even allows multiprocessing—that is, the simultaneous execution of programs on each of the processors. This cannot be done with existing DOS programs, but requires ones written according to the specifications in the technical reference manual provided in a text file on disk.

The user's manual is quite good, but it should have used diagrams instead of verbal descriptions to point out the locations of the many jumpers that must be set during installation. After the board is configured and then plugged into an expansion slot, a set-up program is run to set up configuration files for each processor. The manual also provides sufficient information to allow an experienced user to set up or modify the software configuration manually, without having to go through the menu-driven set-up program.

The board's local 16-bit bus is accessible by means of a double-row Berg connector along the top edge of the board. The primary purpose is to connect to a special model of the Orchid EGA video board, thus placing the video RAM on the 16-bit bus. The pinouts of this bus connector are documented in the manual, allowing the construction of customized add-ons.

Although the Orchid PCturbo 286e is not the fastest of the accelerators tested, its well-designed interface with the host system and its expandability make it an excellent choice among the high-end accelerator boards.

Seattle Telecom & Data (STD). An emulator board with 640KB of memory, the PC-286 is available with clock speeds of 6, 8, 10, or 12.5 MHz for the 80286, and 5, 8, or 10 MHz for the 80287. These speeds must be specified when the board is ordered, as neither can be changed by the user. The unit tested for this review ran the 80286 at 12.5 MHz (the fastest of all the accelerators tested) and the 80287 at 8 MHz.

The standard approach for installation is followed except that the 8088 is not reinstalled on the accelerator; therefore, no provision is made for switching speeds. To complete the installation, all memory on expansion boards in the I/O slots must be removed or disabled. The manual is brief and to the point, consisting mainly of installation instructions. The instructions for connecting the ribbon cable between the board and the vacated 8088 socket needs better illustration because the cable is not keyed at the accelerator end, and the

stripe on the ribbon cable does not go to pin 1 of the socket, which is in direct contrast to standard convention.

Memory expansion beyond 640KB is made possible by the provision for connecting to STD's Top Board, an expanded memory board, via a header cable that extends the board's local 16-bit bus. The combination makes up to 8MB of fast memory available to the 80286, but this memory is all paged, not the AT-style extended memory that is accessible in protected mode.

The STD PC-286 is a simple, no-frills full-complement accelerator that achieves the highest measured performance in this review by using the brute-force method of applying plenty of megahertz. One potential drawback is that it has no fall-back position in cases where its speed proves excessive for a particular program or peripheral.

CACHE-MEMORY BOARDS

In direct contrast to full-complement accelerators, caching boards provide only a small portion of memory space, using it as a high-speed cache. This method of handling memory can result in significant speed increases and for less cost than full-complement boards.

MicroWay. A half-length board with a clock running independently of the motherboard, the FastCache 286 is available in both 10-MHz and 12-MHz models; the latter version was tested, and, along with the PCSG Breakthru 286, is the fastest of the caching boards reviewed. The clock for the 80287 may be set at either 6 MHz or the same rate as the main processor clock; the review unit came with an 80287 rated for 12 MHz. The cache consists of 8KB of static RAM rated at 55 nanoseconds (ns).

Installation follows the standard method. The documentation consists of 15 pages stapled together, but the content is quite good. The step-by-step installation and operating instructions are clear and complete, and diagrams are included of both the FastCache 286 board and the host system's motherboard to aid in locating the appropriate IC sockets, jumpers, and switches.

Speed at power-up is controlled by one of two toggle switches on the rear panel. Switching speeds requires powering down; flipping this switch during operation causes the system to crash. The second switch enables and disables the memory cache; this one can be switched while the system is running with no ill effects. Caching also can be governed by software: either a transient program or a memory-resident program that responds to hot keys.

The MicroWay FastCache 286 operates reliably, and its performance is near the top of the caching boards.

Mountain Computer, Inc. The RaceCard 286 runs at a clock speed of 7.2 MHz, derived from the motherboard oscillator signal. The 80287 clock can be set at either 4.77 MHz (the same speed as the 8088 clock on the motherboard) or at 7.2 MHz. The size of the cache is 8KB. Installing the RaceCard 286 follows the standard approach, except that the 8088, once removed from the motherboard, is not reinstalled on the accelerator. Thus, no provision is made for switching between operating at high-speed operation on the 80286 processor and normal speed on the 8088.

This accelerator is identical to the Victor SpeedPac 286 and its performance reflects that fact. They only vary in the documentation, and even here, the difference is in style, not substance. Both provide adequate installation and operating instructions.

In direct contrast to full-complement accelerators, caching boards make available for use only a small portion of memory space.

Orchid Technology. Whereas this company's PCturbo 286e is an imaginative piece of engineering, its TinyTurbo 286 is a very ordinary caching board with a synchronous clock. This accelerator shares the characteristics of the other boards of this type: 7.2-MHz clock speed, 80287 operation at either 4.77 or 7.2 MHz, and 8KB of cache memory. As a result, its performance is virtually identical to that of the accelerators from Mountain, PCT, and Victor.

Installation is standard, except that the cable connecting the board to the 8088 socket is very short, requiring that the TinyTurbo 286 be mounted in the slot immediately adjacent to the socket. A longer cable can be special-ordered from Orchid for $20. Because no software is provided with the TinyTurbo 286, the documentation covers only installation and operation, which it does more than adequately.

Operation on the 80286 or the 8088 is controlled by a switch on the rear bracket. Changing speeds causes a reset, but does not require powering down the system. Caching is controlled by a jumper setting, so disabling it requires opening up the system unit.

Personal Computer Support Group (PCSG). Running faster than most of the caching boards, the Breakthru 286 has a 12-MHz asynchronous clock. The speed of the 80287 may be set at either the PC motherboard's rate of 4.77 MHz or the accelerator's own 12-MHz speed. The size of the cache is 16KB instead of the usual 8KB. As a result of the high clock speed and large cache, its performance leads all the caching boards tested.

Jumpers enable the caching of code from ROM as well as code and data from motherboard RAM. In the test system, however, enabling ROM caching rendered the diskette drives unusable, presumably because the timing routines in the ROM BIOS run too quickly. All attempts to access the diskette drives result in a "general failure" error. The manufacturer confirmed that ROM caching is not possible with certain versions of the BIOS and certain models of disk drives. Accordingly, all performance tests were recorded with ROM caching disabled. RAM caching may be turned on and off by running a utility at the DOS prompt or from a batch file, but no provision is made for disabling the 80286 and running on the 8088.

Installation follows the usual pattern except that the 8088 is not reinstalled on the accelerator board. The installation instructions are adequate, but somewhat frustrating because they describe the process three times. First, a half-page overview is presented, then a two-page summary for experienced users, and finally a step-by-step procedure giving the full details. Only the detailed description is self-sufficient. For example, the location of the jumpers for setting the clock speed for the 80287 is given only in the full description, but to find it the experienced user is forced to wade through yet another description of how to remove the system unit cover and identify the 8088 and 8087 sockets on the motherboard. Worse, the 80287 socket on the Breakthru 286 board is notched at both ends, requiring careful scrutiny of the documentation to determine the chip's proper orientation.

Apart from the installation instructions, the manual is quite good. It includes a large amount of technical description of the design, detailed information on installation in a Compaq, and general aspects of installation in clone systems. Overall, this is the best of the caching boards reviewed because of its operating speed and the quality of the technical material included.

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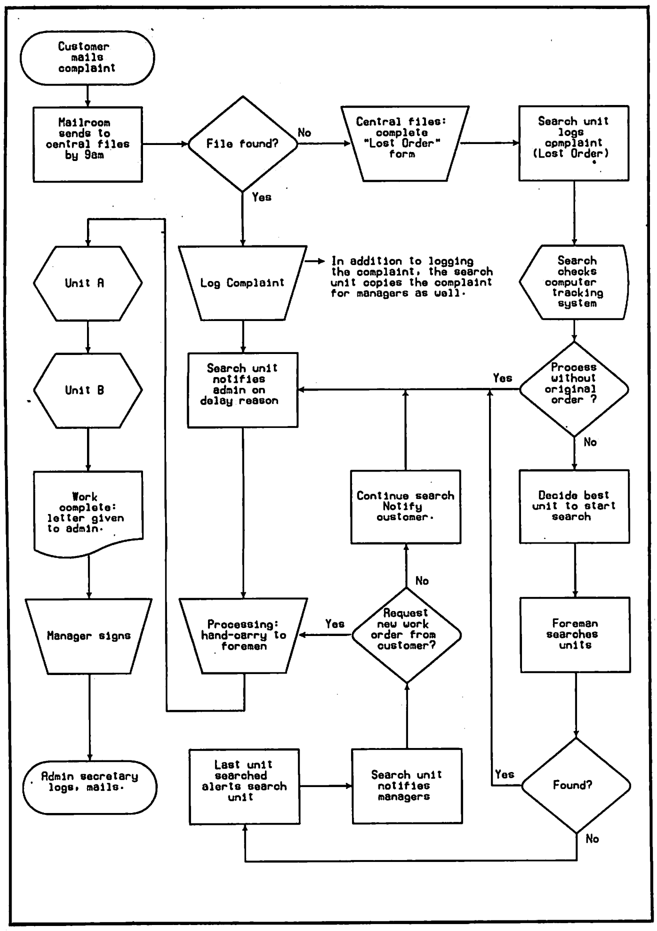

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PC Technologies, Inc. (PCT). The 286 Express accelerator card derives its clock speed from the motherboard oscillator signal to run the 80286 at 7.2 MHz. The 80287 may be run at either 4.77 or 7.2 MHz; the tests were performed at the higher speed. The amount of cache memory is 8KB. Installation is standard.

A switch on the rear bracket chooses between 80286 and 8088 operation. Unlike some of the other boards, the 286 Express allows this selection to be made while the system is running. Flipping the switch resets the system.

Caching may be enabled or disabled by running a DOS utility or by installing a resident program that reacts to hot keys. The assembler code sequence for controlling the cache is also given. The documentation provides detailed installation instructions for IBM, Compaq, and Leading Edge computers, but is short on technical details.

Although the PCT 286 Express Card provides overall performance that is about on a par with the other synchronous caching boards reviewed, it does not distinguish itself from them.

Sigma Designs. The TurboCache 286 is unusual among the caching accelerators because it is a full-length board. The reason is that it accepts a video adapter on a daughterboard; either a standard EGA or a color card with a resolution of 640 by 400 pixels may be added. Video I/O will then be performed via a 16-bit bus, potentially speeding up the display performance of the system. Because a video adapter has no bearing on the board's acceleration, the unit tested did not have one installed.

The asynchronous clock rate is 10 MHz for the 80286; the rate for the 80287 can be set to one of four speeds between 4.77 and 10 MHz. The fastest speed was the one used for this review. As shipped from the company, the cache consists of 16KB of memory; it may be increased to 64KB by replacing three static RAM chips. Installing the TurboCache 286 follows the standard procedure in all respects. Documentation is good, with adequate illustrations in place of lengthy descriptions, but the advanced user will not find much in the way of technical information.

A toggle switch on the rear bracket determines whether the system boots up on the 80286 or the 8088. Flipping this switch when the system is running causes a reset, but it does not require powering down the system. The TurboCache is the only one of the caching accelerators that allows switching between processors by means of software and hot keys. Thus, it is possible to start a program at slow speed (to get through a copy protection scheme, for example) and then to switch it into high gear to actually run the program. The only complaint about this switching scheme is that the switching program must be resident in memory. Preferably, the user should have the option of running a transient program to avoid tying up memory or causing conflicts with other memory-resident programs.

The Sigma TurboCache 286 provides reasonable performance for a caching board, and its method of switching between processors is the most flexible of the caching boards. The add-on video capability of the TurboCache 286 could be especially important for systems that need extra video display performance or those that are short of expansion slots.

Victor Technologies, Inc. The SpeedPac 286 is identical to the Mountain RaceCard 286; the only difference between these two synchronous accelerators is in the documentation. Although both adequately describe the installation, operation, and specifications of the accel-

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S I G M A D E S I G N S

TABLE 2: *286 Accelerator Performance*

	FULL-COMPLEMENT ACCELERATORS				
	IBM	**ARC**	**CLASSIC**	**ORCHID**	**STD**
MODEL	PC/AT	PC-elevATor	286 SPEED PAK	PCturbo 286e	PC-286
MEASURED CLOCK RATES (MHz)					
80286 clock	8.0	10.0	8.0	8.0	12.5
80287 clock	5.3	7.2	5.3	8.0	8.2
MEMORY ACCESS[a]					
Wait states	1	0	1	0	1
Bus bandwidth[b,c]	4.51	8.34	4.19	7.01	7.14
BENCHMARK RESULTS[c]					
ATFLOAT	1.84	2.65	1.95	2.73	3.15
Assembly of VDISK	3.87	5.39	3.54	4.36	5.68
1-2-3 recalculation	4.10	4.10	1.50	4.55	4.00
dBASE sort	1.98	1.18	1.14	1.75	1.21
Word repagination	3.85	4.76	3.57	5.00	5.55

[a]For caching boards, access is to system memory, not the cache.
[b]Measured with the BUSPERF program.
[c]Values are ratios of the speed to that of a standard PC running at 4.77 MHz.

erator, the Victor manual has one glaring omission: it does not list the address and telephone number of the manufacturer. These are found only on the outside wrapper of the box and on the warranty card, neither one of which is likely to be available if problems arise after the installation is completed.

As expected, the performance of the SpeedPac 286 is identical to that of the Mountain RaceCard 286, and very close to that of the other two synchronous caching boards (PCT 286 Express and Orchid TinyTurbo 286.) The choice between the Victor and the Mountain board, and indeed any other cache memory accelerator that operates at 7.2 MHz, boils down to price alone because their features and their performance are virtually the same.

COMMAND PERFORMANCE

The system in which these boards were tested was the same one used in the previous two articles of this series: an IBM PC-2 with two 360KB diskette drives and a Seagate 20MB hard disk, 256KB on the motherboard, backfilled to 640KB by an AST RAMpage board containing a total of 2MB of memory. Other boards in the system were an IBM CGA and a Xebec 1220 diskette/hard-disk drive controller. The same test programs were used, but they were augmented by test equipment. The results are listed in table 2.

The clock speed measurements were made with a frequency counter. In most cases, the measured results confirmed the published clock rates, but some manufacturers state nominal rates that are slightly above the actual performance. For example, the synchronous boards nominally rated at 8 MHz actually run at 7.2 MHz.

The bus bandwidth was measured with the BUSPERF program, published in part 1 of this series. BUSPERF measures the execution time of a straight-line sequence of instructions that take longer to fetch from memory than to execute. Because processors of the 8086 family overlap execution and instruction fetching, the elapsed time measures only the longer of these activities, which indicates how much time it actually took to transfer a known amount of data from memory to the processor.

BUSPERF measures only the bandwidth to main memory, not the bandwidth to the cache. The results are reported as a ratio to the bus bandwidth of the base IBM PC running at 4.77 MHz—that is, the numbers in the table indicate how many times faster each of the boards is than the standard PC bus.

The number of wait states was determined with a logic analyzer by monitoring the level on the NOT READY pin of the accelerator board's processor.

The performance results are reported in table 2 relative to the speed of a standard PC running at 4.77 MHz. The same results for an 8-MHz AT, also relative to the PC, are listed for comparison. Dividing each board's results by the AT results yields that board's performance ratio relative to the AT.

MEASURING UP

Although the measured results are spread out over a factor of about three, subjectively the boards can be grouped into two broad categories. The ARC PC-elevATor, Orchid PCturbo 286e, and STD PC-286 provide an impressive speed-up that is immediately noticeable. For many applications, they match or exceed the performance of an AT. By no coincidence, all of these are full-complement boards, and the cost of providing the improvement can approach that of a low-end AT compatible.

The caching boards provide a lower level of improvement. In most cases, this improvement is not instantly recognizable, but is eventually noticed —especially when compared with an unaccelerated PC. A significant spread is apparent in their performance, however, and the three faster caching accelerators (the MicroWay FastCACHE 286, PCSG Breakthru 286, and Sigma TurboCache 286) provide a subjective increase approaching that of the full-complement boards. For some applications, especially compute-intensive ones, a caching board approaches the performance of an AT at a cost that is a great deal lower than either a full-complement board or a complete 80286-based system.

In choosing from among these products, the differences between the classifications (caching versus full-complement, coprocessor versus emulator) are more significant than the differences between the boards in any one category. In the full-complement category, the flexibility offered by the coprocessors makes them preferable to the emulators, with the Orchid PCturbo 286e comfortably in first place, followed by the ARC PC-elevATor as a reasonable second choice. In caching boards, the products that rise above the rest are all three of the asynchronous designs: the MicroWay FastCACHE 286, PCSG Breakthru 286, and Sigma TurboCache 286.

CACHE-MEMORY ACCELERATORS

MICROWAY	MOUNTAIN	ORCHID	PCSG	PCT	SIGMA	VICTOR
FastCACHE 286	RaceCard-286	TinyTurbo 286	Breakthru 286	286 Express Card	TurboCache 286	SpeedPac 286
12.0	7.2	7.2	12.0	7.2	10.0	7.2
12.0	7.2	7.2	12.0	7.2	10.0	7.2
10–11	4–5	4	10–11	4	8–9	4–5
0.80	0.97	1.00	0.80	1.00	0.80	0.97
3.42	2.28	2.25	3.56	2.25	3.09	2.28
2.00	2.05	2.06	2.86	2.07	2.91	2.05
1.55	1.40	1.40	1.55	1.40	1.52	1.40
1.19	1.19	1.20	1.20	1.17	1.18	1.19
2.39	2.38	2.38	3.20	2.38	3.21	2.38

Some of the 80286 accelerators exceed the performance of a PC/AT on compute-intensive operations. The figures for the asynchronous caching boards illustrate the trade-off they have made of lower bus performance for higher clock speed.

The design of all the accelerators shows attention to software compatibility. Except for obsolete versions of copy-protected software, no significant commercial applications failed to run with any of these boards installed.

Given the complexity of these products and the potential for compatibility problems, the high degree of reliability and the ease of installation and operation are very commendable. None of them had any recurring problems; any problems that did come up were promptly solved by the technical support personnel of the respective manufacturers. In terms of reliability, compatibility, and support, all of these products are almost equivalent.

A BOARD FOR THE FUTURE?

The question of whether an 80286 board can turn a PC into a reasonable facsimile of an AT cannot be answered categorically. For some purposes, an accelerator can match or exceed the AT's speed of computation. For others, the slower hard disks available for the PC will limit its performance to something less than the AT's level.

Regarding compatibility with the upcoming OS/2, the outlook is unclear. It is safe to say, however, that caching boards cannot support a protected-mode operating system because they do not have a protected address space. On the other end of the spectrum, coprocessor boards have a much better chance of being compatible because they do provide the memory and bus structure specific to the 80286. But problems might arise because these accelerators are not designed primarily for protected-mode operation.

This is not to say, however, that a PC equipped with an 80286 board is not capable of running OS/2. Once that operating system becomes well-known, designing a board for it, in all likelihood, will be technically feasible. It is highly unlikely, however, that these existing boards conform to the requirements of OS/2. Therefore, consider an 80286 accelerator for providing all or part of an AT's performance with current applications and systems software, but not for converting an old PC into a machine for the future.

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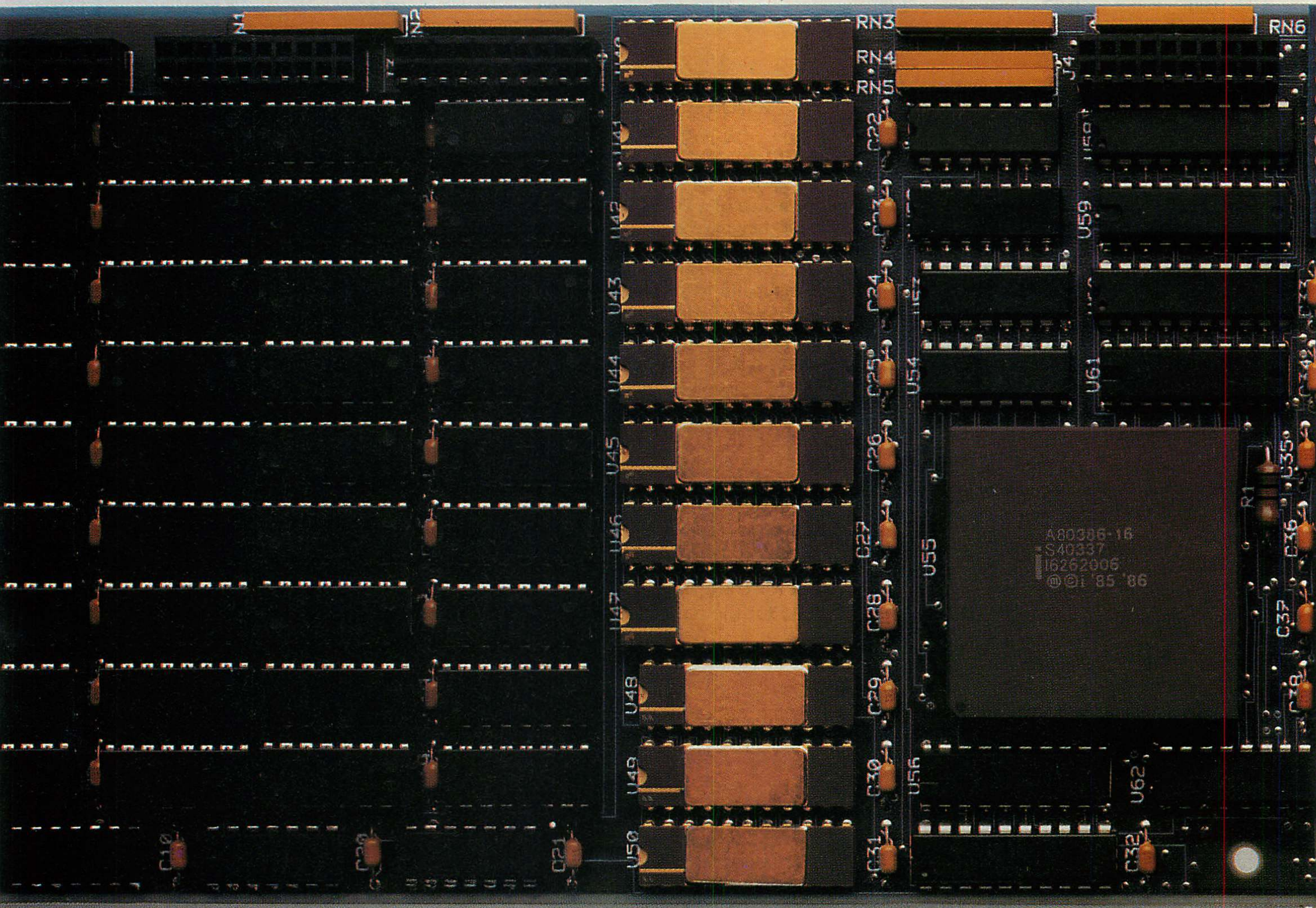

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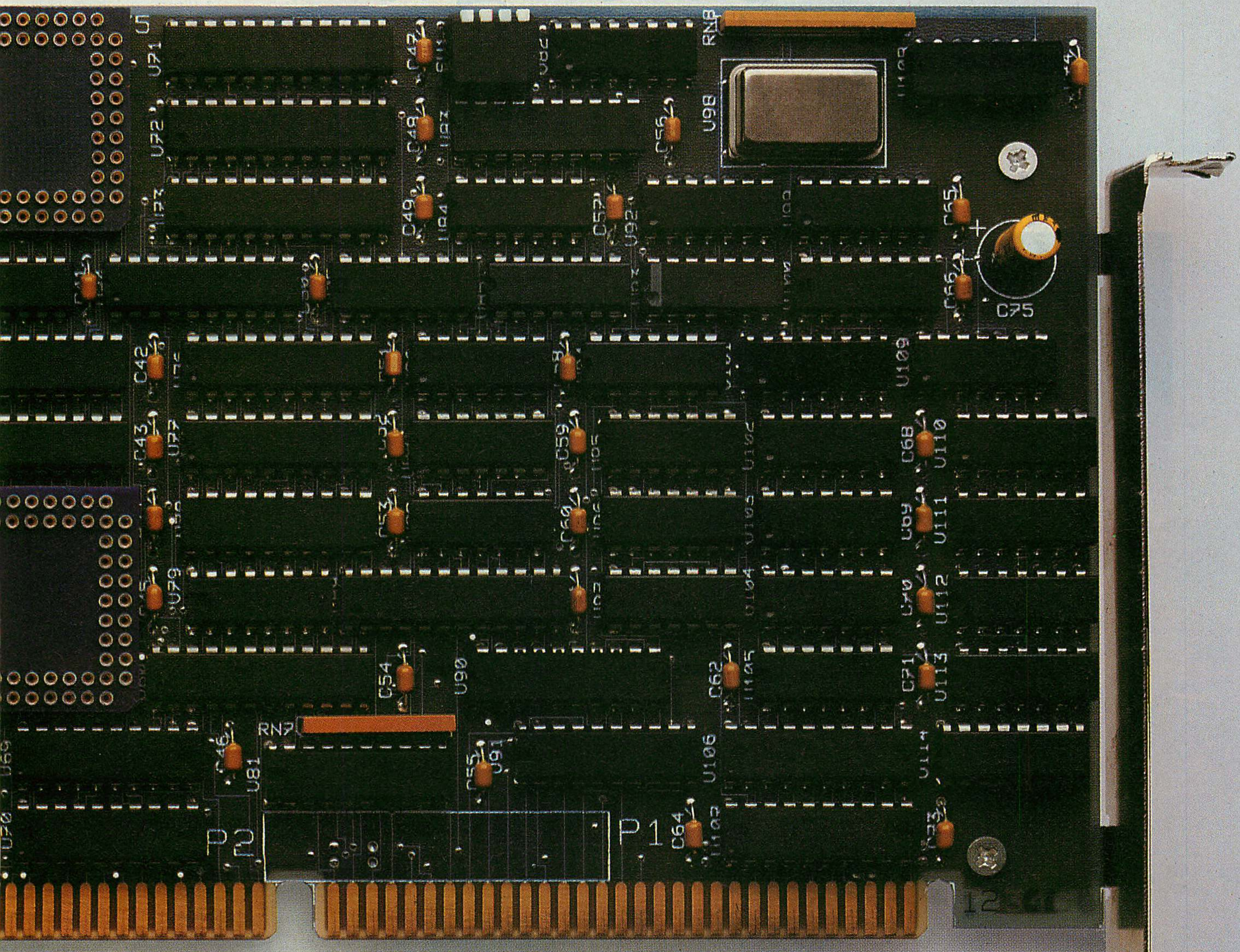

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UNIFY, the high-performance data manager in control of half the UNIX market, saw its first release in a DOS translation in the summer of 1986. The new DOS UNIFY 3.2 was updated in March 1987 to provide improved SQL performance, NetBIOS LAN and Microsoft C version 4.0 compiler support, and to drop copy protection. The single-user version of release 3.2-870325.2 is reviewed here.

This data manager brings with it an unfamiliar look to users accustomed only to the microcomputer: it uses no color screen displays, no drop-down or pop-up menus, no zooming, and no windows—except what might be programmed. Moreover, UNIFY will be virtually unusable to a person not comfortable with the principles of relational databases. No, UNIFY is not slick in its appearance or ease of use, but rather internally, in the speed and integrity of its data management and database administration. Although many DOS data managers provide reasonably adequate data management, they generally falter in database administration. To this area, DOS UNIFY brings welcome relief.

But the DOS market is thick with data managers that serve most programmers and users reasonably well, and some are easier to use, at least in the early going. UNIFY's cost alone—$795—could be an obstacle to the developer hoping to use it as the engine for a commercial product. The single-user runtime licenses cost a few hundred dollars or less, depending on volume.

What, then, is the market for this product? UNIFY Corporation sees it as consisting of its existing base of UNIX developers, who can market scaled-down versions of their existing applications for customers not yet looking for a full multiuser system; corporate and institutional UNIX users, who may want to run their existing software on an inexpensive workstation; and high-end DOS VARs (value-added resellers), who require a more comprehensive data manager for the DOS environment.

But the company may be too modest. Any user who has access to programming support and who is managing a sizable database at a workstation should consider DOS UNIFY. The painstaking work required initially is rewarded farther along, and accompanied by good support and regular upgrades. Once the application developer or database administrator learns what UNIFY expects from him, and the interface becomes comfortable, this data manager gives the very reassuring feel of a well-engineered machine. Its combination of powerful database administration, speed, and a consistent behavior will instill confidence in any developer.

The package requires about 512KB, thus a good 640KB is recommended to accommodate other resident software or a disk cache. The user also should take heed that portions of UNIFY are not compatible with some memory-resident software, such as Borland's SideKick.

The documentation comprises three manuals: a tutorial, a reference, and a programmer's manual. In all, it comes to about 900 pages in standard-size, three-ring binders with slip covers. The UNIFY program and help files are distributed on fifteen 360KB diskettes.

The features of UNIX UNIFY that are not yet available in DOS UNIFY include raw file systems for fast access (DOS is faster than UNIX on random reads, so this is not too important), a Ryan-McFarland RM/COBOL Host Language Interface (HLI), and the ACCEL program generator, a distinct and expensive product that has a lot of flash.

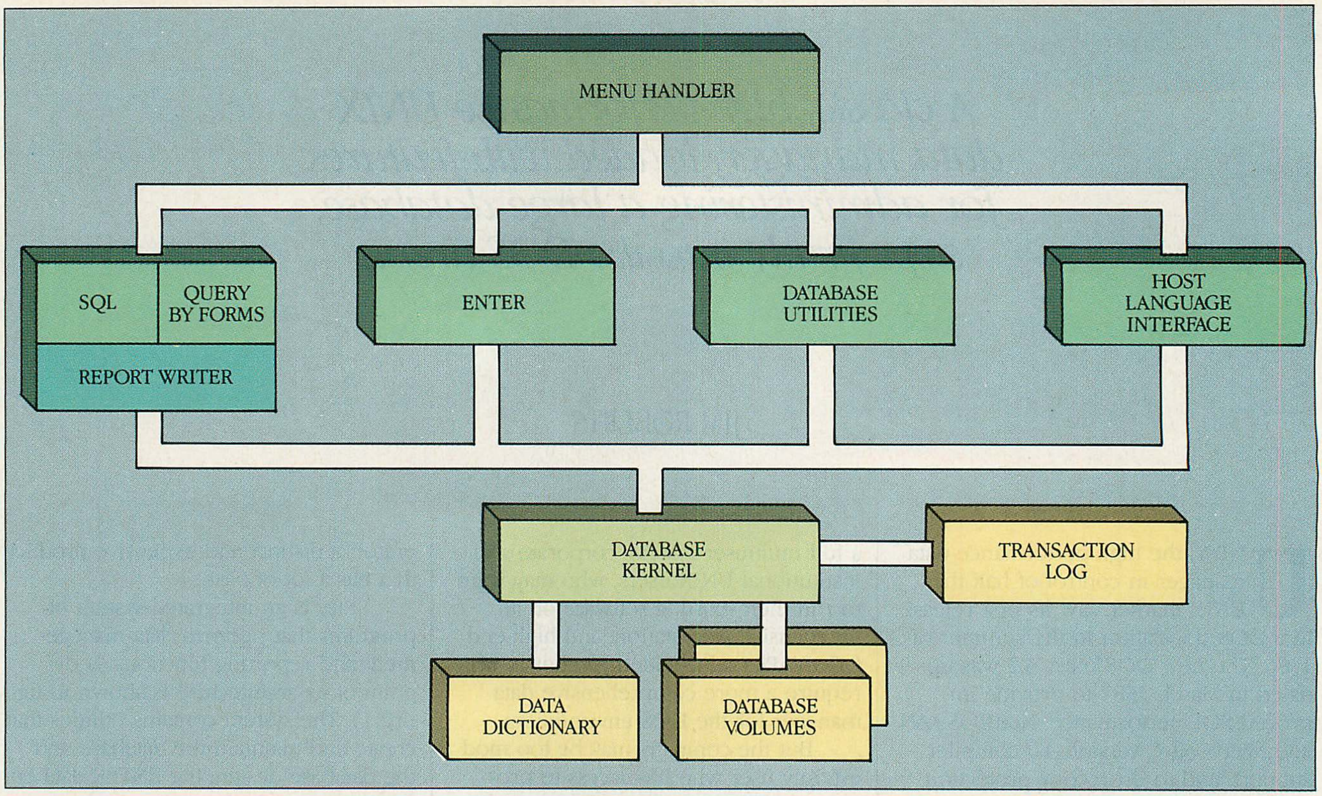
UNIFY is an integrated system of programs that perform data management and reporting functions (a diagram of its architecture is shown in figure 1). The system contains utilities that create and maintain the database and the database design; the ENTER data entry program, which can be used as a query-by-form interface; the SQL (structured query language) processor; the RPT report writer; and the C HLI.

Developer and user alike generally work with UNIFY via a hierarchy of menus, beginning with the main menu shown in photo 1. (In addition, many data inquiry and reporting functions can be called directly from DOS, and the programmer can access UNIFY functions from C.) The operator can either walk through the menus or go directly to the menu desired by entering a system name for that menu in response to the SELECTION prompt. This latter course may seem the easier route; however, the documentation does not include a table of these system names, so identifying them can be a real chore.

The data dictionary is at the heart of UNIFY's data management, in contrast to Ashton-Tate's dBASE, for example, in which fields have no wider a world than the file to which they belong. UNIFY's data dictionary is a much more general entity than the variety usually found in DOS data managers. In UNIFY, the data dictionary includes the full database design, or *schema*, plus the menus, screens, access privileges, help documentation, and program list.

With the relational model as its basis, UNIFY adds one feature that either violates the model or extends it, depending upon your point of view. A

FIGURE 1: *UNIFY Architecture*



Adapted from UNIFY documentation

UNIFY is a compilation of more than 20 programs that provide an integrated system for creating data management systems.

strictly relational data manager confines defined relationships to tables. Tables are independent in the database schema, therefore all look-ups or dependencies must be programmed. In UNIFY, however, the relationships between two tables can be defined in the schema itself. A field in table A can be related explicitly to a primary (hashed) key in table B. This is called an *explicit relationship* or *link*. Once established, UNIFY keeps a pointer in table B to the corresponding unique record in table A. This advance information greatly speeds joins, because no look-up or hashing is required. More importantly, UNIFY permits fields from two tables to be placed on the same data entry screen *only* if the tables have already been linked in this way, although it does not limit the number of tables that can be represented on the same screen using this mechanism.

Explicit links between tables are useful not only for performance in look-ups and joins, but also for data integrity. A record in a table cannot be deleted if its key has explicit links from records in another table. Thus, in a real accounting application, customers could not be deleted if they have outstanding orders. Similarly, orders could not be entered unless the customer is already present in the customer file. The failure of such referential integrity is one of the most common problems in simpler data managers. This integrity is also the most ubiquitous, though annoying, safeguard that must be programmed into a complex application. UNIFY saves the programmer a great deal of trouble with this feature, but the manual offers only obscure information about it.

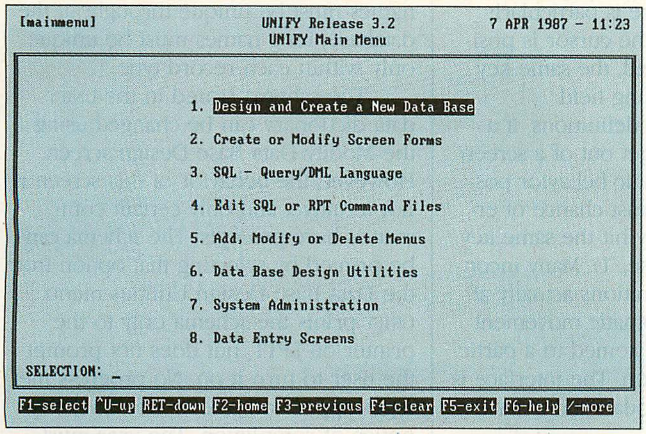
UNIFY's data (field) types are familiar, so although the manual does not define all of them explicitly, their definitions usually can be inferred. However, this treatment does seem negligent, for example, with the extensively used numeric data type. A definition is not provided, yet these data have two different internal representations. Values with four or fewer digits are stored as short (16-bit) integers (as defined by C), and values with five to nine digits are stored as long (32-bit) integers.

Float is another numerical type not clearly defined. In the tutorial and reference manuals, it is treated as a binary-coded-decimal (BCD), floating-point number with no exponent. A little digging in the programmers' manual, however, reveals that internally it is identical with the C type double (not float), that is, double-precision floating-point, or 64 bits. Float fields can use exponential notation, but the range of magnitudes available for input or output nevertheless is limited by the number of significant figures, which is 17. Exponents larger in magnitude than 16 are invalid as input, although they can be represented internally. Float fields cannot be output in exponential format. This limits UNIFY's usefulness in design, engineering, and scientific applications, as does the fact that it does not support the Intel numeric coprocessors.

Another numerical type, amount, always has two figures to the right of the decimal point. The manuals do not explain this choice, but it is easy to surmise. Shorter fields of type amount are saved internally as long integers, longer fields (8 to 11 digits) as double-precision floating point. Thus, this field type is treated as two types internally.

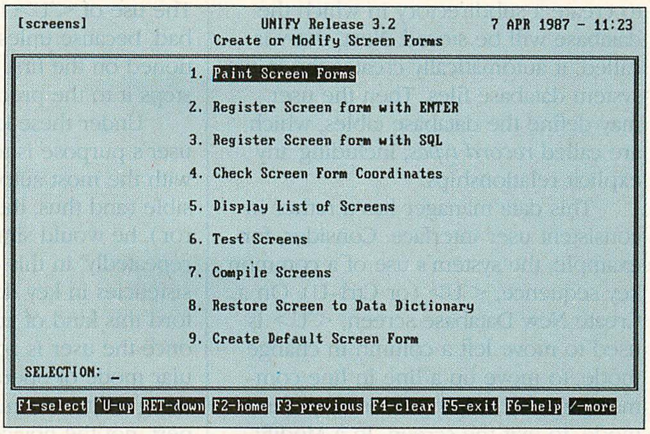
The date type field can be expressed in three formats: *mm/dd/yy*, *dd/mm/yy*, and *yy/mm/dd*. No format is provided for representing the month in text (Jan., Feb.). The default date type can be specified globally through an environment variable, but may be overridden on a field-by-field basis. Regrettably, the range of valid dates presently does not extend outside the 20th century (a limit not stated clearly in the documentation). This will handicap

PHOTO 1: *Main Menu*



Developers and users alike usually deal with UNIFY through a hierarchical set of menus beginning with the main menu. Function key F1 is pressed to select the specified entry.

PHOTO 2: *Create or Modify Screen Forms*



This menu provides a variety of screen-related services. Screens can be generated, tested, and registered with the ENTER program for use in performing data queries.

UNIFY in applications for science, history, bibliography, and genealogy.

The time data type, *hh:mm*, is limited also. It represents a time of day, not a quantity, and seconds cannot be included. Two different times may be subtracted, as long as the result (in minutes) is positive; times may not be added. (Some far less expensive DOS data managers have far more powerful float, date, and time data types.)

UNIFY also includes a string data type, the values for which are stored internally as C language type strings. Strings have a maximum length of 256 characters, with no variable length memo or text data types, nor any logical types. Also supported is a combined (COMB) field type. A *combined field* is an associated group of previously defined fields. The associated fields, which are referenced by implication whenever a COMB field is referenced, are called *implied fields*.

A table can have as many as 256 fields to a maximum record length of 25.6KB. A database can have a maximum 2 billion records and 256 distinct tables. These limitations are generous, and are exceeded by very few other DOS data managers. The number of secondary keys is limited to 255, which may seem restrictive, but UNIFY has powerful sorting capabilities in both its query language and report processor.

UNIFY offers four methods of accessing records, while many data managers provide two at most. All tables must have a primary key, which is hashed for fast look-up; secondary keys are indexed as balanced B+ trees. Beyond these two random access methods, records may be accessed sequentially in the order they are logically stored on the disk, or via the pointer method used in explicit relationships. UNIFY itself apparently chooses the fastest access method, depending upon the procedure and database schema.

The procedure language of most data managers for the PC fits into one of three categories:

- Those that run applications in interpreted form, generating screens and reports at any time, and that have no compiled form (dBASE, for example). These require the full development system to run a program.
- Those that compile all modules to intermediate token code before they can be run (Data Access's DataFlex, Business Tools' TAS-Plus) or that can compile and run each module at any time (Fox Software's Foxbase+).
- Those that compile all modules to native code (dBASE compilers such as Nantucket's Clipper and WordTech Systems' Quicksilver). The compiled programs stand alone.

UNIFY, however, fits none of these categories. Its applications exist in two radically different forms. The procedural language intrinsic to UNIFY is the IBM Structured Query Language (SQL) with extensions (this also is implemented in Oracle's DOS Oracle and Micro Data Base Systems' KnowledgeMan/2). Procedures in this language are ASCII files, and hence are interpreted by the SQL command processor.

The other UNIFY application available under DOS is compiled native code, using the C HLI and the Microsoft C Compiler 4.0. These routines are compiled into native code that makes calls to the UNIFY library of data management routines. UNIFY provides no token code form.

GETTING PAST INSTALLATION

UNIFY's installation guide indicates that DOS 2.0 or later is required, but that network support requires DOS 3.x. The DOS UNIFY 2.0 release notes describe the various updates in the most recent UNIFY release (including Microsoft C support). A guide to converting UNIFY applications between DOS and UNIX versions is provided.

The UNIFY data manager requires the ANSI.SYS driver to be loaded through CONFIG.SYS, even though UNIFY does not make full use of the driver. Because colors are not supported, any attempt to redefine screen colors using ANSI.SYS produces only atrocious-looking screens that misbehave. Neither will UNIFY tolerate any redefinition of the function keys. (It is worth noting that few other programs at this level cause a problem with redefining function keys.) When finally installed, with no databases defined, UNIFY occupies about 4MB of disk space.

A word about directory structure under UNIFY. The program is installed in various subdirectories under a main directory called \UNIFY, which is virtually empty. The main UNIFY engine is in subdirectory BIN, the libraries in LIB, and the help files in LIB\HDOC. Every UNIFY application is completely independent. The programmer may place any number of these independent databases and their programs in separate subdirectory branches under \UNIFY.

The product comes with a program that fills the TUTORIAL subdirectory branch, which also contains the database that the new user should have produced upon completing the UNIFY tutorial. The initial tutorial is located in the MYTUTOR subdirectory.

CREATING A DATABASE

The operator's first step is to use DOS to create a subdirectory in which the database will be stored. Next, UNIFY is called; it automatically creates the initial system database files. Then the user may define the database tables, which are called *record types*, including any explicit relationships.

This data manager has a rather inconsistent user interface. Consider, for example, the system's use of a common key sequence, <^U> (or Ctrl–U). On a Create New Database screen, <^U> is used to move left a column in change mode, to move up a line in line command mode, and, in screen command mode, to exit the screen. In a Modify Data Base Design screen, <^U> saves a record type to the database schema. In a data entry screen, <^U> saves and clears the record buffer. The <^U> key is also called the "up" command key, which is defined only for menu handling, when a help line is displayed at the bottom of the screen. When that help line is not present, the command key functions are not available. (Incidentally, the help line is displayed in two separate lines that the user must toggle between—even though the information easily could be written in one line.) It is unfortunate that such confusion remains in UNIFY's user interface. Certainly, it makes an already complex program all the more difficult to grasp.

Once record and field types have been defined using menus, UNIFY gives the user the option of creating an empty database and default data entry screens for each data type. Then data are entered using the generated screens. At this point, both the tutorial and reference manual refer to "primary and secondary record types" without defining either. As it turns out, a primary record type is the primary data file displayed on the screen. Secondary record types are those tables accessed by way of explicit relationships between tables. Many UNIFY security features are implemented in the screen forms: restrictions can be set on the authority to use the form and the modes of the form (add, inquire, modify, and delete). Authority privileges can be assigned on both individual and group basis.

The entry screens display only one record at a time. Data cannot be entered in a browse mode—although such a facility would greatly enhance UNIFY's ease of use. When data entry for the record is complete, pressing <^U> saves the data and clears the buffer. A better method would be for the program to ask whether the record should be saved after the last field has been entered, with a default answer of yes. The use of <^U> here is particularly bad, because unless the cursor is positioned on the first field, the same key steps it to the preceding field.

Under these key definitions, if a user's purpose is to get out of a screen with the most automatic behavior possible (and thus, the least chance of error), he would simply hit the same key repeatedly, in this case, ^U. Many inconsistencies in key definitions actually afford this kind of automatic movement once the user is accustomed to a particular mode of operation. The interface is designed to accommodate the UNIFY expert, not the novice.

Unfortunately, none of these operations is explained in the manual. The table of command keys, listed with their alternate definitions (^U, ^X, or ^K), is not a substitute for an explanation. The reference manual does describe the process for redefining command keys by modifying the UNIFY **unicap** file; however, the process is complex and must be performed with care.

The database schema (design) stored in the UNIFY data dictionary can be changed and output to a printer via menu screens.

The field editing provided by UNIFY is primitive. If the user notices an error while still in the field, he must destructively backspace to the error, then retype; otherwise he must retype the entire field. The PC's arrow keys do not operate, and no insert mode is provided. This is probably the most primitive field editing facility available in a data manager that costs more than $50. Only printable 7-bit characters can be entered; 8-bit characters are truncated to 7. Further, foreign characters are not accommodated—for example, entering a Ü (9AH) truncates to a ^Z, which clears the field.

Field names can contain upper- and lowercase letters, numbers, and the underscore. Although the manual does not state it as such, each field must have a name unique to the entire schema. Actually, each field has two names associated with it—a short name (up to 8 characters) used internally by UNIFY, and a long name (up to 16 characters) used by operators to reference data. Short names must be unique throughout the database; long names must be unique only within each record type.

The schema stored in the UNIFY data dictionary can be changed using the Modify Data Base Design screen. However, the behavior of this screen is not intuitive, and only certain commands have prompts. The schema can be printed by selecting that option from the Data Base Design Utilities menu. UNIFY prints the schema only to the printer on LPT1, but does not prompt the user to turn it on. No progress messages appear on screen, nor does any notice of completion. The user must discern that the process is complete from the printer's inactivity. The printed product is partly a schema description and partly an audit report on the changes that have been made. This report is very valuable in the maintenance and documentation of a complicated database, and is an example of UNIFY at its strongest. In addition, UNIFY prints complete documentation on any or all data entry screens from the Data Dictionary Reports menu. The format is not particularly compact; however, large-scale database development projects, for which UNIFY is intended, benefit greatly from such reports.

Thus, where most DOS data managers are deficient in their ability to document themselves, UNIFY excels. The other side of this coin is that a program with UNIFY's power and complexity is not suitable for the quick-and-dirty projects that can be accommodated on most other data managers. It may be worth noting, however, that those kinds of projects usually develop into big ones, and either outgrow their DOS data manager's capabilities or remain crippled by them.

UNIFY permits restructuring of the database if a field or index has been added or changed, and backup to an external medium before the restructure. By default, the output device for the backup is drive A:. A different receiving device can be specified using the environment variable BUDEV.

UNIFY will generate default entry screens during the database creation process, based on the existing database definition. If changes are made to the database schema, the screens are not modified automatically. If a user is satisfied with the default screen format (which is quite primitive in appearance, but not necessarily in behavior), he can recreate the default screens after a change to the schema. Otherwise, the

UNIFY OVERVIEW

UNIFY 3.2
UNIFY Corporation
4000 Kruse Way Place
Lake Oswego, OR 97034
503/635-7777
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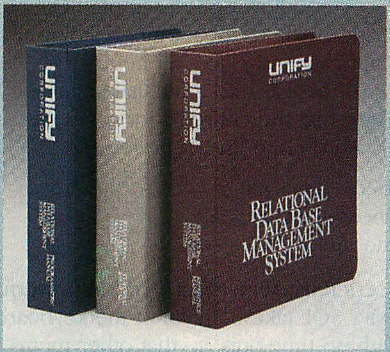
Product type. UNIFY is an interactive relational data manager, with a structured query language (SQL) and a C language interface. Data fields (attributes) are single-valued. Primary key in each table is hashed, secondary keys are B-trees. The relational model is extended by explicitly defined relationships (prejoins) between primary keys and fields in other tables. System data dictionary includes all menus, screens, access privileges, help documentation, and program list. Application data dictionary places all record type definitions. field types, and hash tables in a single file. B-trees are kept in separate files, one per record type.
IBM PC environment. UNIFY runs on an IBM PC or compatible with a hard-disk drive and 640KB recommended, running DOS 2.0 or later; UNIFY does not use extended or expanded memory. Requires 4MB of disk space for system. Numeric coprocessor not required or supported. Also requires ANSI.SYS screen driver and DOS printer spooler. C language interface uses Microsoft C 4.0.
Other environments. More than 100 computers from micro to mainframe that run UNIX System V.
Network support. Multiuser version provides NetBIOS LAN support for 4-, 8-, 16-, and 32-user configurations.
Copy protection. None.
Documentation. Three manuals in 8-by-9-inch, slip-covered three-ring binders: tutorial, reference, and programmer's (in all about 900 pages.) A reference guide booklet, and a companion programmer's guide are also included. Documentation describes database design principles and UNIFY operation.
User interface. Data management functions accessible from DOS, or can be



built into the menu system. Operation of data administration through menus.
Help facilities. On-line help for command keys, control keys, and use of system menus. Help on SQL usage available from within SQL.
File capacities. The maximum number of fields in a table is 256, to a maximum record length of 25.6KB. The maximum number of records in a database is 2 billion; a database can have at most 256 distinct tables. Secondary keys limited to 256.
Field types/capacities. Long and short integers, numeric float with 17 significant figures (exponential not supported), money (amount) field, date type restricted to 20th century, partially implemented time type, strings. In addition, these simple types may be combined into a C structure that constitutes a single combination field. No logical, or variable-length text data types, and no arrays.
Data entry. UNIFY generates rudimentary data entry screens for every defined table. These screens may be modified extensively without programming, and also can serve a query function (query-by-forms). Filters, uppercase, forced entry, and other editing functions must be added by the applications programmer.
Application development facilities. Structured Query Language/Data Management Language (SQL/DML) provide simple procedural language for powerful queries and database updates. Data from SQL may be input to RPT report processor. Access to data management primitives in function calls from C language. No access to query language from C.
Security. Password security may be applied to menus and programs, and individual database fields.
Access to system facilities. Programs and batch files can be executed from either UNIFY menus or a secondary COMMAND.COM.
Query and sorting. Very powerful IBM Structured Query Language included, with nesting and restricted regular expressions. Output can be sorted on any combination of fields.
Reporting. Nonprocedural report processor, RPT, produces extremely complex multipage reports from ASCII input generated by SQL. RPT has no direct access to the UNIFY database.
Utilities. Powerful data administration utilities: backup, transaction logging, replay of transactions, rebuilding hash tables and B-tree files, and multilevel access security. Referential integrity is guaranteed by explicit relationship links between tables.
Data compatibility. Data can be imported from delimited ASCII files, without quotes. SQL or LST list processor will export to fixed field-length delimited files; RPT must be used to produce variable-length delimited files. With some limitations, data can also be imported from UNIFY databases on other machines.
Distribution. Direct sales to VARs and large corporate users.
Price. DOS UNIFY single-user version, $795. Runtimes start at $400, with per-unit reductions for volume. Multiuser version for 4-, 8-, 16-, and 32-user configurations—prices are $1,695, $3,195, $6,195, and $11,995, respectively.
Support. Full telephone support with free upgrades, $750 annually. Written support and discounts on future upgrades, $500. Discounts on new releases, but no support, $300. Telephone support is a toll call.
—Jim Roberts

PAINT facility must be used to modify the generated default screen forms.

PAINT is invoked from the Create or Modify Screen Forms menu (see photo 2). This facility permits the user to enter field prompts, move and delete fields, and add fields from the same table or fields from another table explicitly related to fields in the current table in the schema. Fields and field windows can be located anywhere on the screen, except the last three rows.

This facility does have a few flaws. For one thing, its text is difficult to read on a color screen. It displays field prompts as white, which is acceptable, but the field type markers (NNN for a three-digit numeric field, SSS for a string field, and so on) are shown in a deep blue on a black background. (These appear as underlined text on an IBM monochrome monitor.) One restrictive feature is that PAINT determines the field entry order: left to right on a row, then top to bottom. If this order is deemed awkward or otherwise unacceptable, then the screen must be

programmed in C—this is probably the most difficult and error-prone portion of any UNIFY application development.

When fields are defined in the data dictionary as the schema is first set up for a database, field attributes such as case are not specified. Hence, the default entry screens generated by UNIFY cannot incorporate such information. The only data validation possible in the screens at the field level is whether the data being entered is consistent with the field type. Values entered for related fields must be present in the file to which the field is explicitly related. Thus, these master files, with primary keys explicitly referred to in other files, must be filled with their master data before dependent data can be entered.

SQL/DML

IBM'S SQL has long been a standard on mainframes and minicomputers. It is destined to become a standard for upscale DOS data managers for the PC as well. SQL provides powerful, flexible data selection tools, without reports, that are uniform across hardware, operating systems, and programs. It is also quite approachable, even for nontechnical personnel. UNIFY offers a full implementation of SQL, but UNIFY SQL is extended beyond the pure inquiry function to selectively modify the data. In this capacity, it is called the Data Management Language (DML).

The following is a sample SQL script that finds all authors residing in California and places all fields from those records into a file called **autdoc**. (Note that the entire script could be placed on one line, if preferred.)

```
select * from author
where stcode = 'CA '
into autdoc /
```

Users must remember that the powerful UNIFY SQL takes control of the keyboard with no time-outs, so that other memory-resident routines that query the keyboard (such as SideKick) are locked out. Such a situation can require a warm reboot if SQL will not relinquish control—this is a serious flaw.

SQL can be run from the UNIFY menu handler or from DOS or batch files. Two versions of SQL are provided: the standard version (used when SQL is run from the menu handler) consumes less memory, but runs slower; the enhanced version (used when SQL is executed from DOS or batch files) runs faster, but uses more memory.

The SQL help facility provides very useful on-line reminders about SQL syntax, but it has a few minor glitches and opportunities for the user to err. The help screen for the **select** key word, for example, is too big, so part of it scrolls off the top before it can be read. The **fields** help screen lists the fields in any record type, so it must be followed by the name of a record type. If fields help is requested without specifying a record type, the user is dropped back to the **sql>** prompt without an error message, and the program waits for the record type to be entered. At that point, if fields help is requested again with the correct syntax, the program issues an error message. As with other components of UNIFY, requests for help must be handled with care.

When an SQL query has been parsed correctly, UNIFY responds with "recognized query." This message is issued because executing an SQL query can take some time, and the operator of a multiuser machine needs to be reassured that he has not hung the system by asking something impossible.

UNIFY SQL uses long field names in queries, rather than the short ones. A typical user will be entering similar queries again and again, and so would have the opportunity to become quite familiar with the short field names. The only time they are used, however, is in references to components of combination fields. The access name for such a field is a composite of the combination field's short name and the short name of the referenced component field. So, although the user must become familiar with the abbreviated names, they may not be used directly.

SQL queries can be saved in text files. UNIFY allows the user to specify his own editor by using the environment variable EDIT. This editor is then summoned whenever the user selects edit from the main menu or issues the edit command in SQL. This is an excellent feature, especially if the user's editor supports macros. The default editor for UNIFY is DOS EDLIN.

The editor specified in the environment can be one that accepts a configuration file on the editor command line. The configuration file cannot be specified directly, however EDIT can be set to the name of a batch file (without the .BAT) that contains the editor invocation complete with the configuration file specified on the command line.

In a way, SQL scripts are similar to DOS batch files. They may be executed by entering them interactively to the SQL script interpreter, or placing them in separate text files, the names of which are passed to SQL as arguments in the DOS command line. Regrettably,

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these SQL script files cannot possess replaceable parameters unless these parameters are passed to it by UNIFY, not DOS. That is, an SQL script with replaceable parameters must be "described" to UNIFY, so that when it is called, the actual values of the parameters must be passed. The user must edit the SQL script file to change the actual field values being used in the inquiry—not a difficult task, just awkward.

The tutorial chapter on SQL does not explain the language syntax, but does offer a very intelligible set of examples of its use. Although this is a reasonably good introduction, it would be even better if the actual syntax were included in some form. Also, some of the operations in the tutorial do not work as advertised. The most annoying was an import of data from a fixed-length ASCII query file, using the "insert" clause (command). The tutorial gives the specific command for loading the data from a different directory, but it simply does not work and no error message or status report is generated. Several variations were attempted; the only way the command would work was by copying the ASCII data files into the logged directory.

Many of the SQL commands could be implemented more efficiently by UNIFY. For example, SQL permits selective deletion or counting of records that meet certain criteria. However, the operator often wants to delete or count *all* records. In these cases, UNIFY SQL chews through an entire file, record by record, rather than using a higher level of database information.

SQL easily exports data from a UNIFY database to an external, delimited ASCII file. However, this file will have fixed-length fields padded with blanks to their defined lengths. UNIFY technical support personnel reports little demand for variable-length delimited output because UNIX has so many powerful and efficient text manipulation tools for stripping out unwanted blanks, and to make other desired modifications. DOS UNIFY users may want to acquire some of these UNIX-like tools from the public domain. As an alternative, RPT can be used to export variable-length delimited fields; the simpler LST list processor prints only fixed-length fields.

One annoying trait of UNIFY's SQL is that it aborts if the operator is trying to use the into clause to direct the results of the SQL query to a DOS file that already exists. Of course, if SQL is being called from DOS, redirection can be used (this process saves to existing files with no problem).

SQL misbehaved badly with the simple script shown in figure 2. This script is meant to generate an input file called **auttemp** for an RPT processor that prints one mailing label for each author and coauthor in an issue. The authors' names are extracted from the article file and their addresses from the author file. This process is called a *join*. This SQL script pulled all the correct authors; however, **auttemp** contained garbage at the beginning and end. A search through the database using UNIFY data entry screens for something that would result in garbage in the tables themselves turned up nothing. The tables displayed correct data.

A discussion of this problem with UNIFY technical support personnel revealed a problem with UNIFY's implementation of SQL. As noted previously, UNIFY has extended the relational model to allow explicit relationships between tables. SQL uses these explicit relationships to optimize searches. SQL's use of the explicit join between the author and article files makes it unable to correctly process this specific query. Unfortunately, the SQL processor bravely went ahead anyway, doing the best it could, and producing garbage (along with correct results). This problem can be avoided by splitting the query into two separate queries (the output for which goes to the same file) or by structuring the database without an explicit relationship. The lesson here is that although explicit relationships are useful in searches, they can cause problems with syntactically correct SQL queries. Thus, reliable data extraction requires a knowledge of both the database schema and the SQL syntax.

REPORTING

The UNIFY utilities available for creating attractive or complex reports are LST, the listing processor that can produce sorted, formatted output from multiple files, with totals and subtotals, and RPT, a very powerful, nonprocedural reporting language. LST has all the features that most users would need for quick reports, and its syntax is quite simple. It consists of a selection processor that selects records from a UNIFY database, and a listing processor that sorts, formats, and totals the selected records. Regrettably, LST is poorly documented, with not a single example included of a LST script. LST can be run either from the UNIFY menu handler or from DOS or batch files. Running them directly from batch files provides the flexibility of DOS redirection and piping. RPT has no interactive mode; it must be run from

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FIGURE 2: *Mailing Label Query*

```
lines 0/

select unique author.ln, author.fn, addr, city, stcode, azip from
article, author

where [ln = aut1_ln and fn = aut1_fn and avol_vol = 3 and
avol_num = 5]

     or [ln = aut2_ln and fn = aut2_fn and avol_vol = 3 and
avol_num = 5]

into auttemp/
```

This query selects the names of the authors and coauthors in a given issue (for example, vol. 3, no. 5) from the article file and it pulls their addresses from the author file.

FIGURE 3: *RPT Reporting Language*

```
before aut1_ln
print aut1_ln /+ ', ' + aut1_fn in column 5

before avol_vol
skip

detail
print title in column 25 no newline
print avol_vol using '####' in column 86,
avol_num using '####' in column 91,
pmt   using '##,##&.&&' in column 98,
bonus using '#&.&&' in column 110,
comp  using '##,##&.&&' in column 120
```

Some learning time will be required to grasp the reporting language syntax; the documentation does provide several detailed, step-by-step examples of its implementation.

DOS or batch files. RPT scripts can, of course, be edited from the UNIFY menu as can any ASCII file.

RPT has no access to the UNIFY database in the way that SQL does. Instead, RPT gets its data from fixed-field-length ASCII files generated by SQL or LST. These files may be ordinary files, or temporary files accessed through DOS pipes. RPT is adequately, if not completely, described, including samples of fairly complex reports.

Some RPT commands and functions must be inferred. For example, RPT has no documented command to print a disk file. It is left for the operator to determine that RPT prints to standard output, which can be redirected to a disk file. This matter is discussed in the SQL chapter in the reference manual under "Executing Stored Queries." This deficiency in the documentation is no doubt related to UNIFY's UNIX heritage. In UNIX, piping and redirection are basic concepts with which everyone can be assumed to be familiar.

The syntax for RPT scripts will take time to master. (Refer to the fragment of code used to generate one of the *PC Tech Journal* benchmark standard reports, as shown in figure 3.) The correct syntax is difficult to understand from the examples in the manual, thus it is easy to commit syntax errors. In addition, the error messages issued by RPT are generally uninformative (as are those issued by UNIFY SQL, although SQL is easier to debug). When RPT finds a runtime error, it usually does not terminate, and it cannot be interrupted from the keyboard, short of rebooting. Not allowing user-interruption of SQL is reasonable because SQL could be posting transactions to the database, but there is no excuse for locking the user out of RPT.

A word on sorting efficiency (one more subject not covered in the documentation). Both SQL and RPT have the capability to sort data, and obviously it is not necessary to sort twice. Because SQL has full access to the database keys, while RPT must deal with a raw ASCII file, it seems obvious that RPT would always be passed presorted ASCII. However, this is not the case with UNIFY. RPT sorts much faster than SQL, except in cases where the sort is done solely on keys in primary-secondary order.

Finally, RPT exhibits another annoying little glitch in formatting amount fields that are created for money. The user cannot eliminate pennies (even if they are zero) by omitting the fractional positions in a format string if the string has been declared as amount. If this is attempted, RPT will multiply all money by 100 and probably overflow the format strings, in addition to issuing aggressive error messages not listed in the manual (which also, by the way, does not warn about this situation).

ADDITIONAL FEATURES

For the development of a fully integrated, interactive data manager, UNIFY offers several extra features. Transaction logging is the answer for users who re-

quire powerful data-recovery facilities in case of database corruption due to power failures or other mishaps. Each time the database is updated by adding, deleting, or modifying a record, a log record is written. ENTER, SQL, DBLOAD, and the Data Base Test Driver all make appropriate calls to the logging facility. A programmed application also can turn the logging on and off via function calls. However, it is the programmer's responsibility to assure the logical integrity of the database.

The transaction log is used to rebuild the database after a catastrophic failure by the following steps (also called *roll forward recovery*):

1. Read in the latest logically consistent copy of the database (that is, the last available backup).
2. Read the transaction log to get the IDs of all incomplete transactions.
3. Reading the transaction log, bring the database up to date by redoing all updates produced by successfully completed transactions.

Roll forward recovery can be invoked either from the UNIFY menu or from DOS, using the REPLAY command.

Utilities are provided to rebuild the hash tables and B-tree files, in case they become corrupted and begin to give errors. UNIFY generates automatic entry screens (screen forms) for all tables in a database schema. A facility called ENTER can extend these screens to produce queries and reports based on field values entered into a screen, provided they have been "registered" (identified) with ENTER in a prescribed way. The particular screen forms are then tied to ENTER and can serve no other purpose. This query-by-forms process, like PAINT, is initiated from the Create or Modify Screen Forms menu; thus. nontechnical personnel can generate queries and reports without having to write a program in SQL. ENTER uses the input values to extract all records that have fields with the same values as those entered into the screen. The results of this query can be processed by RPT scripts, or any other formatting program, provided that program also has been properly identified to UNIFY.

A developed data management application is ideally run from a set of linked menus. All UNIFY programs, including SQL, LST, and RPT scripts, can be run in this way from UNIFY menus by placing them in batch files and executing the procedure called "describing programs to the menu handler." This function is accessed from the System Administration menu. UNIFY will need to know the eight-character name of the DOS executable file, what arguments will be passed (if any), and an internal menu name that it will use to invoke the program. UNIFY allows the display of a screen form before the program is run, and a message to be displayed while the program is running. UNIFY also must be told which directory contains the program.

Another interesting feature is the database test driver called **sys920**, which permits the entry of test data into a defined database, and verifies the functionality of the attributes and explicit relationships. It helps the programmer to check the primitive data access functions provided in the HLI. The program is executed from DOS in the BIN subdirectory of the application.

Finally, the DOS UNIFY C-language HLI delivers to a programmer customizing abilities beyond the powerful data input, inquiry, and reporting facilities provided automatically with the creation of a database. A free-standing application that will operate autonomously may require the inclusion of many custom features, a task that could prove unwieldy under a strictly menu-driven structure. Furthermore, some essential features of a robust application—special screens or simply easy-to-use entry screens—are extremely difficult to assemble within the base UNIFY system.

This facility should not be confused with the common data access utilities provided in various packages for C programmers to write data management programs. The HLI is highly integrated with the UNIFY database schema and provides more than 100 sophisticated low-level functions that aid in the maintenance of data integrity, as well as data access. These functions provide access to databases; allow records and fields to be selected and modified; and data to be transformed, formatted, displayed, and printed in a comprehensive manner. This combination of full access to the procedural features and system functions of Microsoft C, as well as the data management capabilities of UNIFY, permit the construction of very sophisticated applications.

HLI's one noteworthy deficiency is its failure to provide access to high-level SQL functions: HLI is primarily a low-level language—an assembly language of data management. By contrast, some other DOS data management systems allow the programmer to embed query language commands in a program. Indeed, apart from all of the other bugs in this package, this may be UNIFY's most serious weakness for the applications programmer.

DOCUMENT EVOLUTION

The manuals for DOS UNIFY 3.2, although decidedly deficient in some important areas, are a major improvement over those for the previous UNIX product. Moreover, the volume of the material is not deceiving. These manuals are not padded with basic instructions on data management. UNIFY is a complicated, autocratic program with many features: the manuals reveal an earnest tone in a compressed style.

Most tutorials for DOS data managers assume little knowledge of data management on the part of the user—at this stage in the development of data management techniques and practices, this is probably a faulty assumption. How many developers have fumed at the dozens of pages devoted to building a mailing list, for example, while the features of real interest are discussed only cursorily? The UNIFY tutorial is not so condescending. Instead of being a park ranger leading the reader on a gentle stroll over the local nature trail, the UNIFY tutorial is an Alpine guide hustling him up the Matterhorn. Such a pace is necessary, though, for UNIFY is indeed a Matterhorn compared with the general hilly run of DOS data managers.

The tutorial manual takes the user through the creation of a prototype wholesale distribution system for hardware tools, including work with UNIFY menus, help text, entry screen forms, and modifying the database and the screen forms. The user will use the SQL, write a report using RPT, use query-by-forms, personalize UNIFY system menus, and assign security for access to the system, menus, screens, and reports. However, no tutorial is included for the use of the C language interface.

After completing the tutorial, the user moves on to the reference manual and the programmer's manual. The reference manual provides specific information on all UNIFY modules, menus, and commands. The programmer's manual assumes familiarity with the reference manual, and that the reader is a competent C programmer. Possibly the most valuable single chapter in any of the material is chapter 2 in the programmer's manual—a short course in designing a database. This chapter merits close and repeated study because errors in design are the main cause of poor performance and ineffectiveness in database applications.

Although a great deal of effort has gone into the new manuals to make them as complete and accurate as possible, serious structural and pedagogical defects remain. Although rich in detail, they are exceedingly weak in definition and explanation. A page showing the system menu tree, for example, is no substitute for an intuitive description of how the program operates. No overview of UNIFY is provided anywhere.

Looking for an explanation of a feature is especially frustrating: the index will offer a number of references, but each makes only an allusion to the feature. Combination fields, which initially appear to be similar to structures in C or to the overlay fields of TAS-Plus, are not defined or explained anywhere. Apparently, the user is expected to pick up the definition inductively by working with combination fields a little in the tutorial. The programmer's manual implies, but does not explicitly state, that they are indeed C structures.

In addition, UNIFY Corporation does not seem to have made a firm decision as to which of these manuals is the true *reference* guide. The reference manual, for example, refers to the tutorial manual in many places for a more complete exposition of a feature or operation.

The manuals come with sets of update pages, each sheet carrying about 10 changes. In view of the length and detail of the modifications these sheets contain, it would be far better if UNIFY would instead send entire replacement pages—that is, after all, the major advantage to packaging documentation in a loose-leaf format. Also enclosed with the manuals are an extremely handy reference guide booklet and a companion programmer's guide.

It is important to note also that this DOS translation of UNIFY has not been converted completely from the UNIX environment. It still must read a **termcap** file (implementing ANSI.SYS). The manuals are so littered with references and discussions that are correct only for UNIX that no one should use the DOS version of this program unless he has some prior familiarity with the UNIX operating system and can filter out the confusing material. In the tutorial, for example, in a number of places, the user is instructed to use field names that are legal in UNIX but not in DOS. Consider also the ECHO command: sample batch files derived from UNIX Bourne shell scripts advise opening a file using **echo > <filename>**. This command, of course, puts the remark "ECHO is off" at the head of the file, and ends batch files with the command "ECHO on." DOS, however, always resets ECHO to on at the end of a batch file, unless a copy has been configured to default to off, in which case the user would not want it to switch back on.

The IBM function keys are used in the system menus. As mentioned previously, their definitions are given in a help line at the bottom of the screen, but a template would be helpful. The command keys also have alternate definitions, usually control characters, that are used on terminals. In another indication of the generic nature of the documentation, the IBM function keys appear in only two definition tables and are given no distinct names; they do not appear in the text or in the help screens printed in the manuals. The on-line help is simple, but adequate.

Perhaps more in acknowledgement of the program's complexity than as an admission of weakness in the documentation (although certainly it may prove worthwhile, all things considered), UNIFY Corporation strongly encourages its users to take one of the courses in UNIFY taught in Oregon and New Jersey periodically. These courses include one for applications developers (four days for $995), another on the C HLI (one day for $195), and an overview that is intended for database administrators (two days for $495).

The technical support personnel at UNIFY Corporation are currently much more familiar with the UNIX product than with the DOS. The number of DOS users is still so few (and those who are using this new product are almost all experienced with the UNIX product) that the staff does not have a sufficient solved-problem base to deal confidently with difficulties peculiar to the DOS version. Nevertheless, the support staff seems eager to assist. They appeared competent and were able to handle the few serious problems that cropped up during the review.

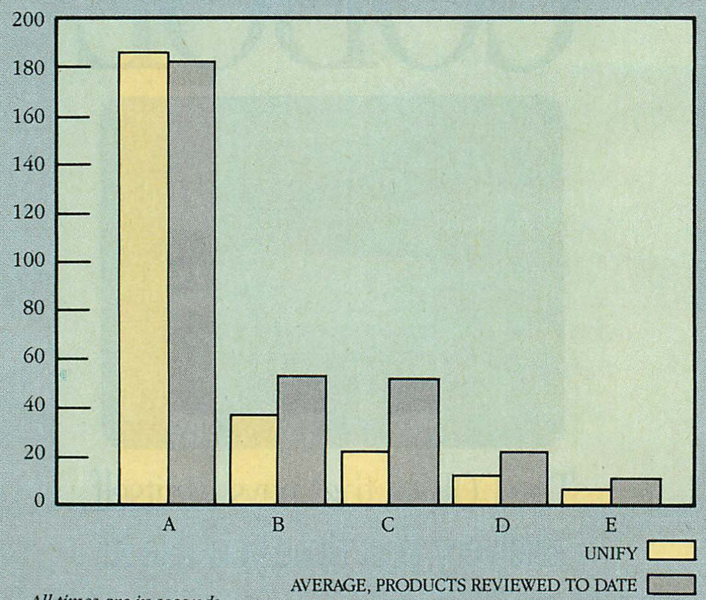
The DOS UNIFY package costs about $800; support is free for 90 days, and the company offers a money-back guarantee for that same period. After that, full support and free upgrades for DOS UNIFY will cost $750 annually. For $500, the user receives written support and discounts on future upgrades. For $300, he enjoys discounts on future releases, but no oral or written support. These are the only programs available.

ADEQUATE, BUT NOT STERLING

In performing the sample application specified by *PC Tech Journal* for all reviews in this series (see "Evaluating Data Managers as Development Tools," Julie Anderson, August 1985, p. 46), the first test is the entry of the database schema. Because UNIFY has an all-inclusive data dictionary, the schema must be specified completely before any part

FIGURE 4: *Benchmark Results*

BENCHMARK TASK	TIME
A. Add 900 records to an empty database table	186
B. Index table on two fields (7 bytes)	38
C. Document and tally codes from one column	22
D. Mass change of one column (28 rows of 900)	12
E. Extract selected records to create a text file	6



All times are in seconds.

All benchmarks were run on an IBM PC/AT (6 MHz) with 640KB memory. The tests were run in an 8MB partition on a CMI 20MB disk under DOS 3.0.

UNIFY was faster than average on all but the first benchmark, and it ran about average on that test despite the considerable overhead added by data validation.

of the database can be created, since it is all done at once. This part of the sample application went without a hitch. (UNIFY's performance in the benchmarks is shown in figure 4.)

The UNIFY reference feature was used to create explicit references among the data files. This makes data validation automatic: for example, only valid state postal codes can be imported into the author file, and only existing authors and issues can be imported into the article file. Of course, these explicit relationships restrict the order in which files can be imported.

All delimited ASCII files used in the sample application were imported using single statements in SQL (aside from setting the separator to , instead of SQL's default |), but the ASCII files had to be massaged first with a text editor to remove the quote marks, which UNIFY treats as field characters.

UNIFY protested at importing a numeric field that was null in the delimited ASCII file, rather that being explicitly given as zero. Even so, the number was correctly imported as a zero. The behavior of DBLOAD also was inconsistent in some respects: the identical file would, at times, have some of its fields rejected and, at other times, not. UNIFY sometimes seemed to want spaces between commas of null fields, sometimes not. In addition, when a variable-length input field is longer than the field length specified in the UNIFY schema, the field is truncated without the program issuing an error message.

The large author data file was imported almost twice as fast into a freshly initialized database, as into one in which the author file had been imported, then deleted, record by record. According to UNIFY technical support, this occurs because UNIFY imposes considerable overhead in reusing deleted records. Perhaps the best advice to anyone importing data to UNIFY is to be persistent—eventually the process will work. When the DBLOAD program is contrary, recreate the database. Of course, this cannot be done if preexisting data are in the target database. In this instance, back up the database and turn on the transaction logging.

As UNIFY is a proven comprehensive data manager, specific benchmarks are not as crucial in this evaluation as for other DOS data managers. More important questions are its ease of use, reliability, and data management features. UNIFY's performance on *PC Tech Journal*'s benchmarks were adequate, but not sterling. Because UNIFY hashes the primary key in every table, indexing would be expected to proceed more rapidly than in good data managers that use only B-trees. Indeed, this was borne out in the tests conducted here. The article file data import benchmark was fairly impressive, because UNIFY performed look-up validation automatically for the author names in the author file (as a result of the explicit relationship defined between those tables). Other data managers in this series did not carry such an overhead, yet UNIFY managed to run at about the average speed in this benchmark. UNIFY was faster than average in its performance of the indexing on two fields (benchmark 2), and even faster in the document and tally codes (benchmark 3), the mass change of one column (benchmark 4), and the selected extraction (benchmark 5).

Seven standard queries in the sample application are designed to test the data manager's interactive reporting facilities. These include printing of certain fields from selected records in the article file, payment totals and averages to authors, total pages devoted to certain types of articles, payments per page, and articles received after the deadline. These queries test selection, sorting, aggregate functions, and the ability to relate more than one file. UNIFY SQL executes these queries with simple, single SQL commands, without nesting. Thus, these queries, which cannot be performed without programming in most DOS data managers, used only the most primitive facilities of the UNIFY SQL inquiry language. The standard sample application reports were generated by RPT with no difficulty.

In all areas, then, UNIFY is a robust, multifeatured, and reliable data manager for the PC. Although newly ported to the DOS environment, for its complexity, it has fewer bugs than might be expected. The documentation does not afford easy entry into the elite world of UNIFY experts, but it does offers the serious developer a direct, if at times rocky, road to mastery of this comprehensive data manager.

Jim Roberts, Ph.D., is an astrophysicist from California with a special interest in data management products.

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Automated Design

Aptos Systems' RGRAPH, a specialized CAD package for the emerging electronics automation market, takes the design of a printed circuit board from a schematic drawing to the final artwork.

VICTOR E. WRIGHT

Over the past three years, the PC-based CAD (computer-aided design) system has evolved from a curiosity into a mature design tool. Microcomputer CAD is used in almost every design field, but for drafting, not design. Few disciplines use their micros to host systems that apply CADD (computer-aided design and drafting) or CAE (computer-aided engineering).

Electronics designers, however, is one group that does. Of course, the design process begins in the mind of the designer, but when the schematic is created using a CAD system, many of the subsequent steps can be performed more or less automatically. The front-end circuit schematic includes logical relations between components that must be consistent with those same relations in the physical board layout. Moreover, the schematic must be such that the designer can infer the physical relationships from it.

RGRAPH from Aptos Systems is an end-to-end system for printed circuit board (PCB) design that offers these sophisticated capabilities. Using its facilities, the designer can create a circuit schematic on the display and produce final artwork for the production of the PCB, while generating minimal paper in the process. Not only can the circuit be designed on a microcomputer, it can be tested on one as well. (Another electronic schematic and PCB layout package is Personal CAD Systems' PCB-3, reviewed in "End-to-End Design," Richard Angell, November 1986, p. 96 and December 1986, p. 155.)

The RGRAPH system (version 1.7) provides the electronic circuit designer with a set of tools that automates tasks ranging from schematic layout to production of final artwork masters on a photoplotter. The system consists of several programs that communicate via a common *database* (in Aptos terminology). First, the namesake program, RGRAPH.EXE, is a specialized CAD system used to create both schematic and physical layout drawings. RCAP.EXE reads the schematic drawing database file and extracts various lists from the file. RSIM.EXE produces input files for simulation programs from a circuit described in a schematic database file. COMNODE.EXE compares schematic drawings with physical layout drawings to locate errors in electrical connectivity. Other RGRAPH utility programs drive plotters and display help messages. The autorouter subsystem, AUTOTOOLS, comprises several programs that also interact with the common database.

RGRAPH also has a substantial library of circuit components. It includes symbols for analog, discrete, TTL (transistor-transistor logic), CMOS (complimentary metal oxide silicon), ECL (emitter-coupled logic), surface-mount, and microprocessor components.

The complete RGRAPH system is distributed on 12 diskettes, 6 containing programs and data files and 6 containing component libraries. The installation diskette also serves as the key diskette for the program's copy-protection scheme—it must be in drive A: before RGRAPH is started. The RGRAPH system flow is shown schematically in figure 1.

The process begins with schematic design created using the RGRAPH editor in a schematic design mode. When this

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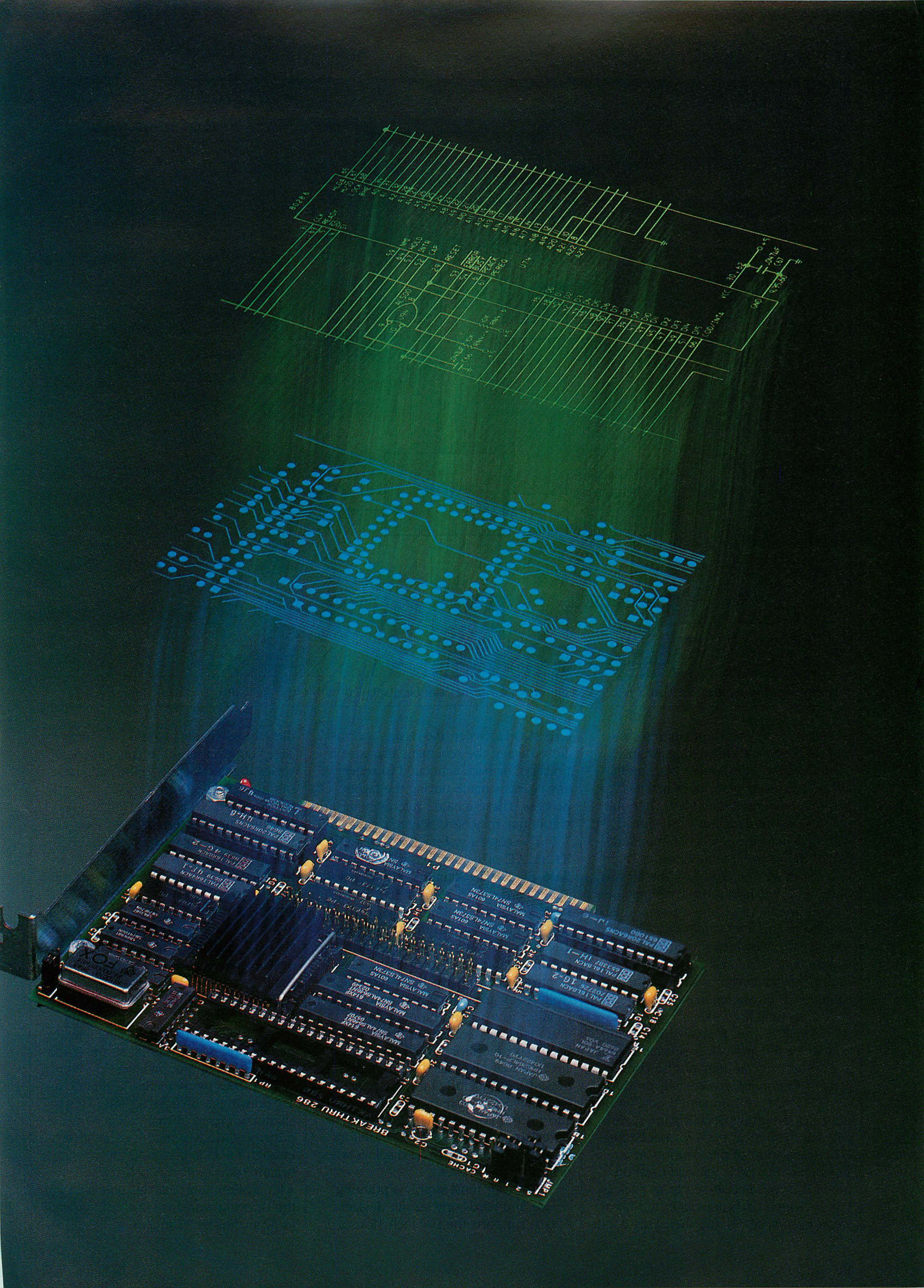
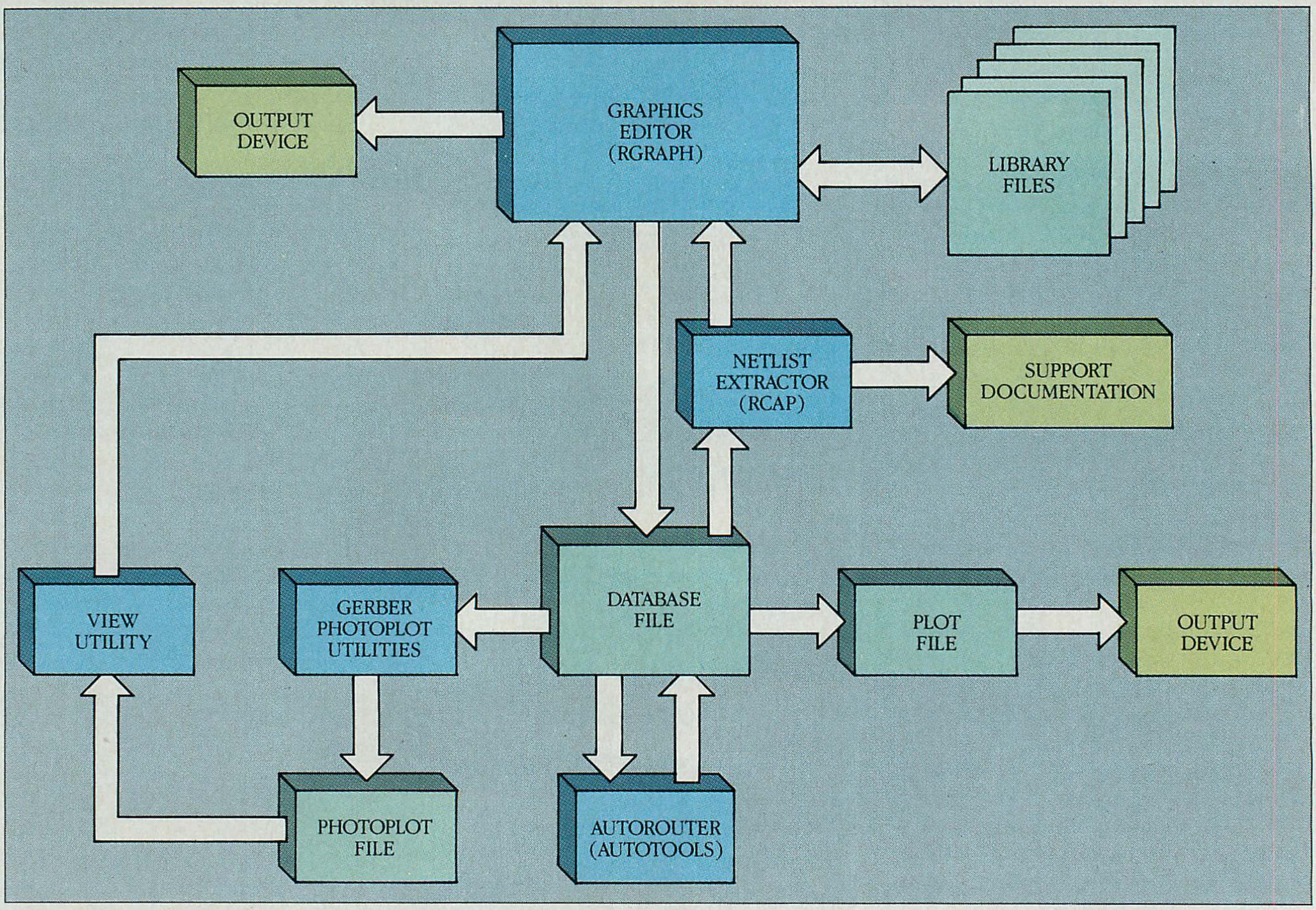

BREAKTHRU 286

FIGURE 1: *Simplified System Flow Chart*



The photoplot utilities convert a photoplot file into a form that can be displayed within the RGRAPH graphics editor.

design is complete, the resulting database is processed through RCAP to extract a net list, component placement, airline (ratsnest) placement macro files, and other optional data files. Then the physical layout database is produced, with optional (though recommended) use of the physical component and airline placement macro files. The airline of the physical layout database may be edited directly to produce a routed PCB or used as input to AUTOTOOLS. The routed PCB, which may or may not be 100-percent routed by AUTOTOOLS, may require manual editing. Finally, the routed PCB layout database is plotted for use as final artwork.

The PCB itself is ready for production when the artwork is produced, but the design process may not be complete at that point. RGRAPH will produce a routed PCB with unnamed nets (conductors), assigning default names, and will select physical parts for *packaging*. (The translation of the symbols in a schematic into parts that are used on the PCB layout is referred to as packaging. Packaged parts appear in the libraries as both symbols and their part counterparts.) However, the design loop is closed when the schematic database is updated, or back-annotated to reflect any changes made during the layout process. These include reference designators that may have been changed.

The RGRAPH system requires a PC/XT, PC/AT, or compatible with 640KB RAM, 8087/80287 numeric coprocessor, 10MB hard disk, 1.2MB or 360KB diskette drive, at least one serial port, and a system monitor and display adapter. The package can be purchased with the required graphics display adapter—a Control Systems Artist I graphics controller—for use with a high-resolution monitor as a second monitor. The program is factory-configured for a Mitsubishi 69xx monitor, which produces a 1,024-by-768 pixel display. Configuration files are included for the Princeton Graphics SR12 monitor (noninterlaced) and for the Princeton HX12 monitor (interlaced). Both Princeton monitors produce 640-by-400 pixel displays when driven by the Artist I.

The user must supply a pointing device and hard-copy output devices. RGRAPH supports the Logitech Mouse, the Mouse Systems Mouse, the Hitachi Tiger digitizer, and the Calcomp 2000 series digitizers. Among the supported output devices are Epson FX printers, the Gerber Photoplotter, Houston Instrument pen plotters, IOLINE pen plotters, the Zeta 822 pen plotter, the CalComp 1043 pen plotter, and any Hewlett-Packard or compatible pen plotter.

SYSTEM ARRANGEMENT

RGRAPH.EXE seems to have been designed specifically for electronic circuit design, but it can be used for general drafting, with a few limitations. The drawing world is 64,000-by-64,000 addressable units, which can represent mils, inches, centimeters, millimeters, or microns. Selecting mils as the name of the drawing unit produces the limits of 64 inches by 64 inches, assuming a 1:1 drawing-to-board-size ratio. This is small compared to that of a general purpose CAD system, but certainly large enough for PCB design. If the design organization performs board layout with a minimum database unit of .5 mil, the drawing world is effectively limited to 32 inches by 32 inches.

The drawing database is also limited in the number of items that it can accommodate. A single database file is limited to 64KB. This limit is misleading, however, because it is not parts that are stored in the database, but rather references to parts. Parts references vary in size, but they generally run about a dozen bytes.

When the drawing is regenerated for any reason, the library files are read for parts definitions. The drawing database is effectively limited to the size of a single 64KB database file plus a maximum 10 library files. Each library file can contain as many as 600 parts, each of which can be approximately 64KB. This evaluates to about 39MB. It is clear that RGRAPH has a substantial capacity—the limitations of the host hardware are more likely to be reached first.

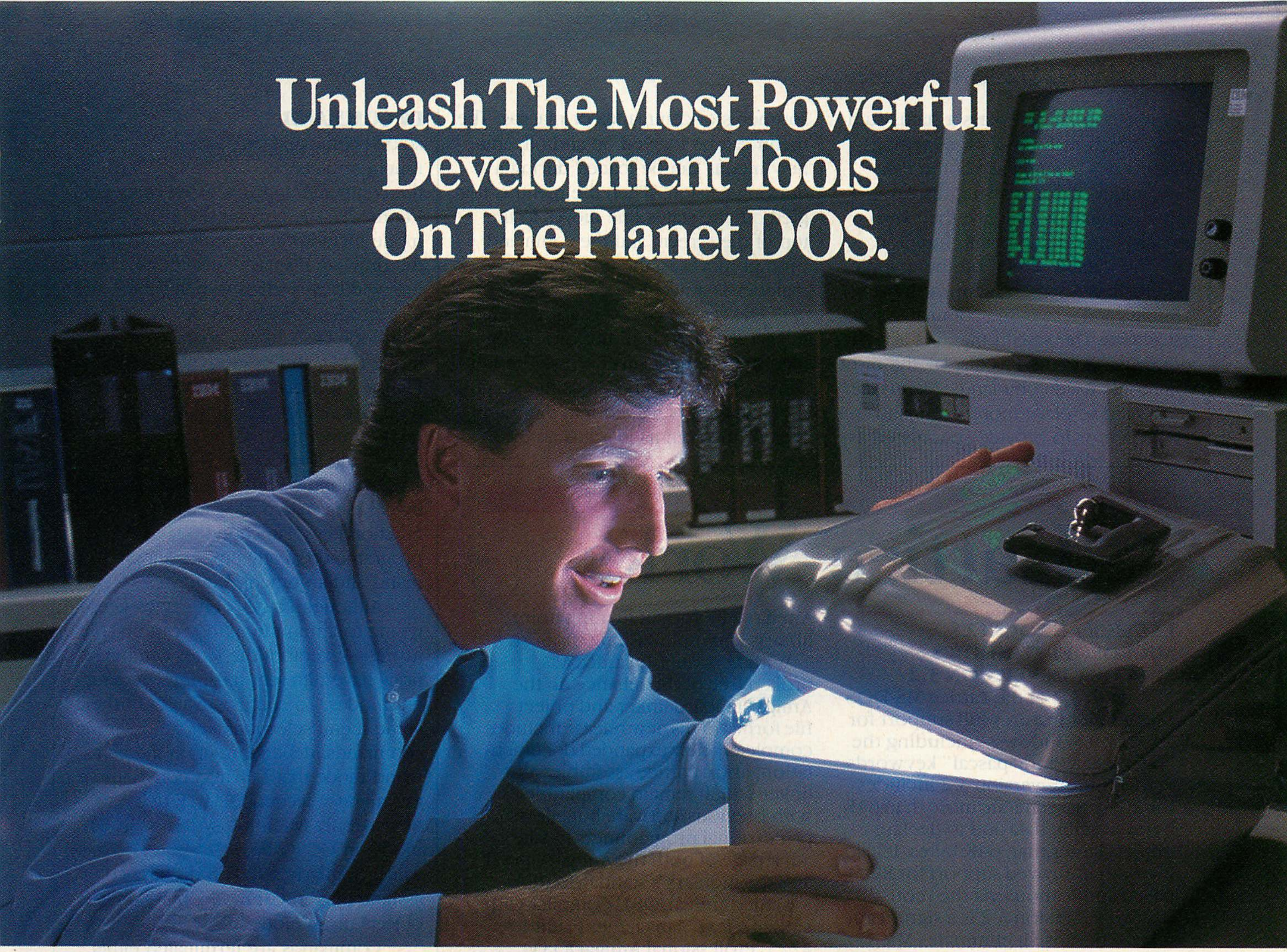
The 64KB limitation allows an entire database to be stored in RAM, which would permit fast regeneration of the database per se. Layers that contain traces or airlines can be redrawn at the speed allowed by the graphics board. However, layers that contain library parts require disk access, and because most drawings contain library parts, RGRAPH is confined to redrawing the screen at the speed allowed by disk access. As with most CAD systems, the screen can be refreshed from memory.

Some RGRAPH commands cause the current drawing to be saved to disk and reloaded after the command (or mode) is exited. The save and reload operations are reasonably fast; they take place at approximately the same speed as drawing regeneration because of zooming and panning.

As for component limitations, a PCB design can contain 1,000 parts, 2,000 nets, and 12,000 pins. A drawing can be organized into 50 layers and 10 hierarchical levels. A schematic design can be organized into 50 sheets, each of which can contain 1,000 symbols, 1,200 nets, and 5,000 pins. In fact, these limits do not result from the database structure, which, by virtue of the large libraries and compact part references can allow very large designs, but from the capabilities of RCAP. More significant is the fact that the limits of the database can be reached and surpassed, with the problem coming to light only when the design is processed by RCAP. Aptos has said that the limitations will be removed in the next release, thus alleviating this problem.

Although the program will run on an XT with a 10MB hard-disk drive, the recommended machine is an AT with a 20MB or 30MB drive. Capacity is the issue. As distributed, the RGRAPH software requires approximately 4MB of disk storage. If AUTOTOOLS is installed on the same computer, an additional 2MB of storage space is needed. If additional parts are added to the libraries, a 10MB disk could quickly become inadequate, even if no other resident software were installed on the system. Large designs can occupy disk storage space on the order of 500KB per design, and parts added to the symbol libraries require about 1KB per part. Even so, Aptos says that a 10MB hard disk can store 20 large designs, along with the system software and symbol libraries, which would seem adequate for a small electronics firm with only a few board-level products in its line. However, a product under development may well be stored in several versions. Thus, storage capacity is a substantial consideration in using this package.

RGRAPH uses the graphics monitor and the system monitor in a dual-screen configuration. The graphics monitor displays the drawing window, an optional menu, and a command line. The system



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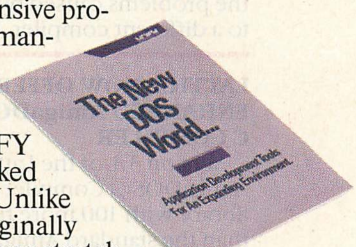

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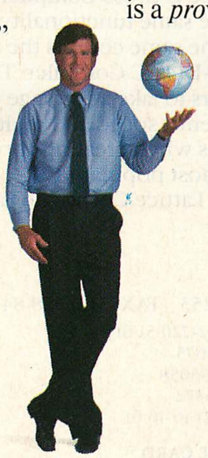

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monitor normally displays a status summary, which includes various settings, toggle states, a summary of the database, and a cursor tracking display. Some commands produce their own text displays on the system monitor.

The default screen on the graphics monitor has a screen menu, a drawing window, and a two-line command and status area. The screen menu is actually a drawing, designed to display the most commonly used commands. Menus can be created to place more commands on the screen or to provide specialized assortments of commands or macros. The menu can be toggled on and off, and new menus can be loaded during a drawing session. When the menu is toggled off, the status line moves to the top of the screen, and the command prompt moves to the bottom. The remainder is available for drawing.

The screen cursor is normally a full-screen cross hair, but can be toggled to become a small cross. The full-screen cursor also becomes the small cross when it is moved into the menu area or the command/status area.

IN COMMAND

RGRAPH commands are two-letter mnemonics, created from key words in the command and organized by operating mode. The general command (GC) mode includes commands to control the drawing display and settings such as line width, as well as to enter the other four modes: drawing mode (DM), identify mode (ID), library management mode (LM), and nesting mode (NE). Figure 2 is a diagram of this organization. Commands can be entered by typing the mnemonic at the prompt, by selecting the appropriate cell in the screen menu with the pointing device, by creating macro files, or by pressing function keys. Function keys can be reprogrammed at any time to supply command and argument sequences.

Although RGRAPH commands keep typing to a minimum, they can be confusing—several of the letter combinations have different meanings in different modes. To confuse matters further, some menu selections invoke different commands, depending upon the command mode that is active. For example, the menu selection DELETE deletes objects only when the system is in ID mode; in GC mode, it sets the grid-lock value. Similarly, STATUS displays color assignments in GC mode, but stretches objects in ID mode.

Commands are terminated either by pressing the Enter key or the second button on the pointing device. Pressing Enter at the prompt repeats the previous command. Some commands—those for line drawing, for example—remain active until specifically terminated (by pressing Esc or the third button on the pointing device). Pressing Esc at one of the operating mode prompts returns the program to GC mode, although ID and LM also provide commands for the same task—QU (quit) and EX (exit), respectively.

RGRAPH provides the usual assortment of drawing aids and a few extras. Zooming is accomplished with no less than three separate commands: SV (set view) corresponds to ZW (zoom window), ZO (zoom) changes the magnification with respect to the current view, and SS (screen scale) changes the magnification with respect to the drawing limits. The latter two commands require positioning the cursor to specify the center of the new view before executing the command. Panning requires specification of the new view's center, rather than a displacement vector.

Two grids are provided in this system—a visible grid of dots and an invisible snap grid. The user can define the

6 MIP GRAPHICS

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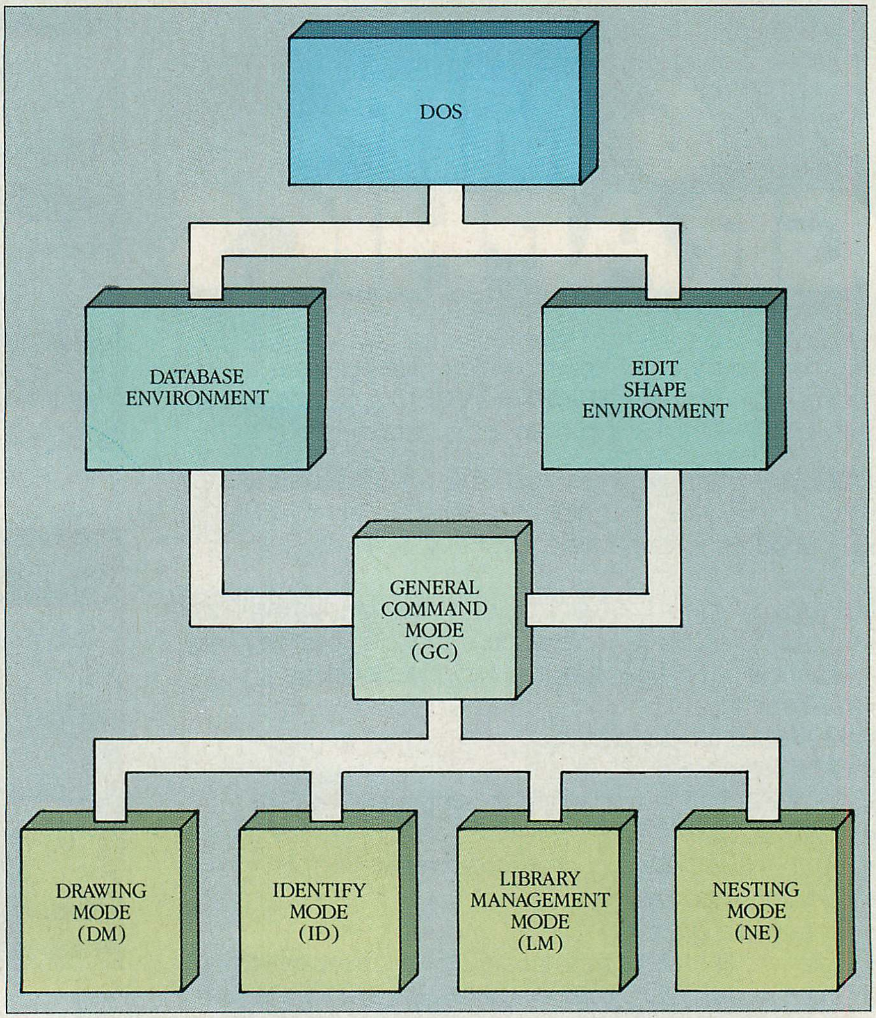
FIGURE 2: *Command and Operating Modes*



Adapted from the RGRAPH documentation, p. 1-9

The RGRAPH command structure has a general command mode and four subsidiary modes; command mnemonics can change meaning in different modes.

spacing of both grids and can toggle either one on or off; that is, the display of the visible grid can be turned off, and the grid lock to the visible grid can be turned on or off. However, the cursor cannot be moved by arbitrarily small distances—the smallest increment is one database unit. A delta x and y setting controls where points can be entered, regardless of the state of the GL (grid lock) and SN (snap toggles).

In addition to the software zoom and pan facilities, RGRAPH provides hardware zoom and pan. The hardware options carry two benefits: their effect is virtually instantaneous, and the commands can be nested within other commands. (Although some of these design systems allow software zoom and pan commands to be nested within other commands, RGRAPH does not.)

Hardware zoom is invoked by pressing Shift-F1 through F8, for one of eight levels of hardware zoom. The first few levels of this zoom are far more useful than the last few. RGRAPH's hardware zoom is accomplished with pixel replication; that is, line widths increase as the zoom factor increases—a line displayed as one pixel wide at a zoom factor of 1 is two pixels wide at a zoom factor of 2. This pixel replication does not improve the resolution of the displayed drawing. Consider, for example, the display of a component with traces routed between pads. If the screen scale is small, the space between pads may be less than one pixel wide. Consequently, the trace may be displayed as being wider than the space between pads—because it must be displayed as at least one pixel wide—even though the space between pads may be wide enough to accommodate two traces.

Hardware pan is available only when zoomed in via hardware zoom. In hardware pan mode, the cursor stays in the center of the screen, and the draw-

ing moves as the pointing device is moved. (Normally, the drawing remains stationary, and the cursor moves with the pointing device.) Standard drawing and editing commands are operational in any of these modes.

Pages are another RGRAPH addition. As many as 50 pages, (also called *views*) can be assigned with the SP (set page) command and recalled with PG (page). RGRAPH pages are assigned the coordinates of their origins and are always recalled with a magnification of 1. Pages function strictly as aids to navigating the drawing. They provide a means of recalling a previously defined view of the screen, but offer no structural relationship between pages.

Finally, the drawing mode includes two other welcome commands in V-ortho (vertical) and H-ortho (horizontal) orthogonal lines. V-ortho draws a vertical line segment, then a horizontal line segment to connect two arbitrary points. H-ortho draws a horizontal segment, then a vertical segment. These commands are particularly useful for wiring a schematic, because two line segments can be entered with two points instead of three.

The RGRAPH assortment of drawing primitives is complete, although the methods of specifying some primitives are limited. Lines and rectangles are entered in the usual way: line segments by end points, rectangles by diagonally opposite corners. Circles are specified in one way only—by picking the center and a radius point. Arcs can be specified by the center and two endpoints and are drawn in a counter-clockwise direction. Text is always left justified, but can be drawn at any angle.

EDITING CONVENTIONS

The RGRAPH assortment of editing commands is quite complete. Segments and vertices can be added to and removed from lines. Attributes, layer assignments, and line widths can be changed, and entities and vertices can be moved. Entities also can be scaled, rotated, and reflected about the x or y axis. Parts can be exploded into their component parts, one nesting level at a time.

Almost all editing commands are entered from ID mode. An entity must be identified before it can be moved, stretched, or rotated. Only entities on the current layer can be identified, unless the A (all) modifier is attached to the command. An attempt to identify an item on a layer other than the current one results in identification of the last item entered on the current layer. Identified entities are redrawn in white.

At first appearance, RGRAPH's layer facility may seem limited, but it is sufficient to the program's task. The system has 50 numbered layers, each of which is assigned a specific purpose within the RGRAPH system (see table 1). If the prescribed layering convention is followed, every feature of PCB design supported by RGRAPH can be accommodated. Moreover, all of the RGRAPH libraries follow the layering convention, and AUTOTOOLS expects to find features according to the convention. Objects can be drawn on the reserved layers, but at the risk of interfering with the operation of certain features in the current or future versions of the product. The concern about this layering system is the use of numbers instead of names. Other PCB design systems use named layers, with predefined, mnemonic names. An Aptos move to a naming convention would be an improvement.

In operation, the layering scheme is restrictive with regard to editing and inquiry. An object must be identified before it can be moved, deleted, rotated, and so on. Further, an object can be identified only if it is contained in the current layer *and* the menu selections I (identify) and IW (identify window) are selected. The experienced user will know which layer contains a

TABLE 1: *Layering Conventions*

LAYER NUMBER	RGRAPH NAME	AUTOTOOLS NAME
1 and 2	Reserved	
3 and 4	Physical outlines	
5	Padmaster	Parts and preplaced vias
6	Solder resist	
7	VSS (ground) plane	
8	VCC (power) plane	
9	Drill targets	
10	Drill codes	
11	Silkscreen/legend	
12 to 16	SMD/LCC pads	
17	Local keep-outs	Component side trace keep-out areas
18	Local keep-outs	Solder side trace keep-out areas
19	Local keep-outs	Component side via keep-out areas
20	Local keep-outs	Solder side via keep-out areas
21 to 30	Traces	Preplaced traces
21 and 30	Component and solder side	
22 and 29	Internal layer pair 1 and 8	
23 and 28	Internal layer pair 2 and 7	
24 and 27	Internal layer pair 3 and 6	
25 and 26	Internal layer pair 4 and 5	
31	Not defined	
32	Ratsnest lines	Ratsnest lines
33	Not defined	
34	Global keep-outs	All layer trace and via keep-out areas
35 to 39	Reserved for future options	
40	Reserved	
41	Router keep-in boundary	All layer routing keep-in boundary
42 to 48	Reserved	
49	Special reference layer	
50	Highlight layer	

The RGRAPH 50-layer scheme is used to control the visibility of database objects and communications among the various phases of the total design process.

given object from the nature of object—component, trace, via, etc. The novice may find the process of locating an object's layer frustrating. Fortunately, IWA (identify window all) is available to identify an object on any or all layers.

Three other attributes—drawing type (absolute or exclusive OR), line type, and color—also are attached to layers. These attributes are viewed using ST (status) and changed via MA (mask). However, changing them is awkward. To change a layer's color and line type, for example, requires constructing an eight-bit binary mask to determine the new attributes, converting the binary number to a decimal number, and then entering MA. (The color and line-type numbers are not listed in the manual.)

SCHEMATIC HIERARCHY

The RGRAPH system establishes a 10-level hierarchical scheme for nesting features in library parts. In effect, this hierarchy in RGRAPH's database structure is an extension of the layer facility. A part can be drawn to include internal details arranged in a hierarchical structure, down to the substrate level if desired. For example, an integrated circuit (IC) could be drawn as a single component at one level, as a group of gates at a lower level, as transistors and so on at a lower level, and as the physical semiconductor elements at an even lower level. The visibility of these various levels is controlled using NE.

If symbols are constructed using existing library parts, according to the conventions of the manual, they will be nested automatically. However, the manual's explanation of this facility is inadequate. In general, the hierarchical scheme is used to control the display of pad stacks and other details associated with parts and to allow the display of such details to be suppressed during the design phase. This selective suppression permits faster screen redraws.

Both schematic design and physical board layout are accomplished with the

single editor, RGRAPH. After displaying the Aptos Systems logo, the program prompts for a database file name, which must be followed by /n if the database is a new one. The program asks if the file will be a schematic database or an artwork database. It then asks for units, a menu file name, and up to four library file names. If necessary, additional libraries can be linked to the database, up to the limit of 10, using the LM command within the editor itself.

RGRAPH's automation of schematic design relies upon the correct use of layers and attributes. Although objects can be placed on arbitrary layers, portions of the system will not function properly if layering conventions are not followed. If RGRAPH's own parts libraries are used, layering and hierarchical conventions will be followed for the parts. Library parts are assigned attributes after they are inserted. Specifically, each part is assigned an *alias*, a name that can be used to identify the part and that is used subsequently in the net list extraction and reporting process.

Interconnecting lines between component pins also must be placed on specific layers. Lines between pins need not be assigned aliases, but lines that are connected only to a single pin must be assigned attributes.

SCHEMATIC EXTRACTION

Once the schematic design database has been built using RGRAPH (and saved as a .DBF file), the schematic extraction process begins with RCAP. This program reads the .DBF file and produces a variety of other files, according to selections made from a menu of nine single-letter commands. The program also operates in a batch mode, reading commands from a command file that is generated by the first selection of the main menu, C (command).

The second selection, I (input), reads the input database file. The input can be a single database up to a maximum of 10. If the database has not been processed by RCAP previously, the program creates a node table for use in subsequent steps of the extraction process. If the program is terminated normally, the node table is saved for use in later sessions; if the program is aborted, the node table is deleted. Finally, if the database is changed and RCAP is rerun, a new node table is created. The node table cannot be printed.

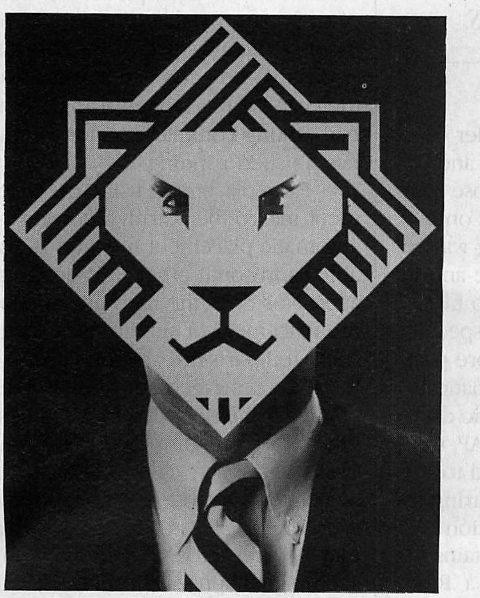
The N (net list) command extracts a generic net list from the database. The net list is an ASCII file that lists each part in the database, along with reference number, alias (reference name), library shape name, shape type, reference page, attributes, and pin connections by net. The B (bill) command produces a single or multilevel bill-of-materials (.BOM) report file that can be printed or edited. This report lists each component in the database, with quantities, descriptions, and references.

Another command, L (list of signals), produces a list of nodes in the database. For each node, the file lists the pins connected by the node as device pin pairs. The R (ratsnest) command produces two macro files that are used in the physical layout phase. The first file is used in physically placing the parts in the PCB layout; the second file is used to draw direct connections between pins in the physical layout.

The W (wire list) command creates a list of point-to-point connections for use in wire-wrapping prototypes. Connections are listed by sequence number, listing two pin pairs for each device, along with the node to which the connection belongs. The last two commands are E (exit), for exiting normally, and Q (quit), for aborting RCAP.

SYSTEM MANAGEMENT

The essence of making good use of any electronic CAD system is in the standardizing of library maintenance and the tying of loose ends through



back-annotation. Care should be taken to ensure that the symbol libraries have corresponding parts libraries and that the packaging file system is suitable. Changes of reference numbers in the PCB layout also need to be transferred back into the schematic. RGRAPH provides all of these mechanisms.

Library parts. Two commands manage the libraries within RGRAPH: ES (edit shape) and LM (library management). ES creates a special environment within RGRAPH, and LM enters a separate mode. ES saves the current database so that the entire database storage area can be devoted to the editing of a single part. The selected part can be any part in an existing library. RGRAPH retrieves the part for editing and allows it to be saved in the same library when editing is complete. LM mode provides the commands to associate additional libraries with the current database and to edit the contents of library files. Libraries can be created and deleted, and their contents listed. Shapes can be deleted and undeleted from a library, and the library files can be packed after shapes have been deleted.

Library parts can be built in a hierarchical structure, as described above, but with limitations. The hierarchy of a part is not dynamic—that is, the relationship between parts and subparts cannot be specified as parts are being inserted into the database. If a shape contains a pad stack with round pads, no means are available to change the pads to oval when the part is inserted.

The designer who needs several versions of a library part does have some options. In the case of pad stacks, several libraries could be maintained, with round pads, oval pads, and square pads on pin 1 (RGRAPH's standard), and so on. Or, before each new design session, the pad stack symbol could be edited to reflect the desired shape, in which case the change would be reflected throughout the various libraries. A third arrangement would be to create separate libraries containing the utility shapes, such as pads, customized to suit the needs of the project or client. Then, the appropriate utility library is linked with the database when it is created. RGRAPH searches for a pad stack and finds a round pad, an oval pad, or even a square pad, depending upon which utility library is linked to the database. The designer must avoid simultaneous loading of two libraries containing parts with duplicate names.

The library management facility also provides a method of handling very large designs in a modular fashion. Each module is created as a database and saved into a library. Then, the various modules can be referenced in a master database. The master database is limited to 64KB as are all databases, but the modules can be much larger.

Packaged parts. The RGRAPH system supports packaged parts—physical packages that contain more than one functional part. Packaged parts are described in .PKG library files corresponding to the schematic and physical parts library files. Package files are ASCII files that can be edited or created from scratch with a text editor, according to a format provided in the manual. Packaged parts inserted from schematic libraries are introduced as individual gates or functional parts. They can be inserted without aliases and connected without regard to the actual packaging.

RCAP automatically packages functional parts according to the parameters of the .PKG file and assigns aliases. These aliases are used in the various files produced by RCAP. In one sample,

RGRAPH provides a single graphics editor for both the schematic design and physical layout, thereby reducing disk space requirements.

RCAP processed a 1-of-10 decoder consisting of ten 4-input AND gates and four inverters, and packaged those fourteen gates into five 74LS21s and one 74LS04, automatically. Packaging was reflected in the bill-of-material file and in the placement and airline macro files. Gates can be prepackaged into specific ICs in the schematic editor before packaging the remaining parts automatically.

Back-annotation. Once a schematic database has been processed by RCAP, the schematic can be back-annotated to reflect pin assignments made during the packaging process. Back-annotation functions only if the design contains packaged parts. RCAP generates a .PIN file, which contains the information required to relate the pins of the physical parts with the components of the original schematic if the schematic contains packaged parts. Pin assignments are made by RCAP in the process of grouping gates into packaged parts, using the information contained in .PKG files and parts library files.

Back-annotation can be performed at any time after RCAP has generated the .PIN file; thus, it requires exiting RGRAPH, running RCAP, and then reentering RGRAPH. The BA command back-annotates the schematic database with pin assignments and aliases. (No mechanism is available for assigning net names at the conclusion of the physical layout process and back-annotating the schematic with those names.)

PHYSICAL LAYOUT

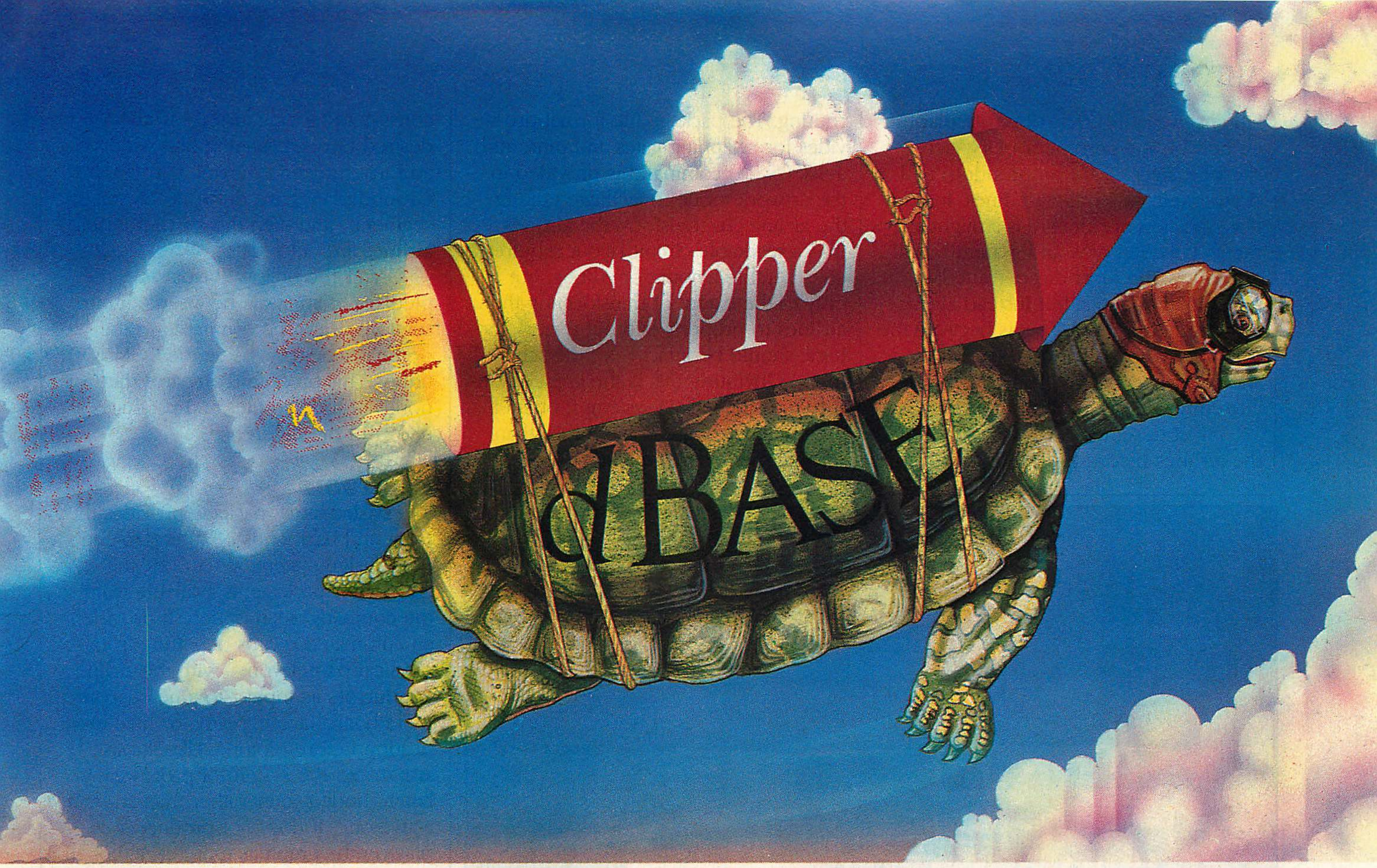
Rather than, as some systems do, provide separate graphics editors for schematic design and physical layout, RGRAPH provides a single program. This reduces disk space requirements and eases the learning process. At the second prompt—following the one for a database name—selecting the artwork option causes RGRAPH to prompt for the name of the original schematic database. If the file is a new one, RGRAPH will prompt for parts libraries, offering the physical parts library counterparts of the libraries used in the schematic.

If the schematic database were created using only parts from the libraries, parts could be placed interactively with the macro files generated by RCAP. Assuming that a board outline has been drawn or retrieved from the library, the .PLC macro file is invoked with the US (use) command. RGRAPH then reads the macro file and prompts for the location of each part, by alias, and for the placement of the alias text. If the first attempt at placing the parts is not satisfactory, they can be rearranged using the normal editing commands, after the macro has finished running.

Parts placement using the placement macro file is truly interactive—no automatic placement function is available as in some other PCB design packages. Nor does the mechanism allow the placement of similar parts in arrays. Packaged parts are assigned aliases by RCAP, as described above, so some unfamiliar aliases will appear unless the bill of material is studied before the placement macro is run. In fact, the placement macro file is not sorted according to aliases, so components may be presented for placement in seemingly haphazard order.

When the parts have been placed satisfactorily, the second macro file, .RAT, is invoked with US. This macro runs automatically, wiring the entire circuit with direct connections to the extent that it was wired in the schematic.

At this point, the RGRAPH system returns the user to a completely manual environment (unless the AUTOTOOLS fa-



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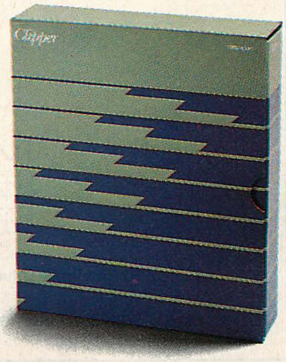

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cility is available). The .RAT file places all nets on the current layer (which must be layer 32 for autorouting) and draws them as 1-mil-wide lines. In addition, the nets are drawn as straight segments between pins and generally will not follow the most direct route between components, but instead zigzag around the drawing. This is because the database is not re-sorted to provide a shortest route for the nets as they are currently laid out in the PCB editor.

Most designers will prefer to edit the airlines before proceeding with routing. The package file format provides for swapping gates and pins, and a SW (swap) command is provided in the artwork mode to facilitate editing the airline. To transform the airlines into a workable circuit layout requires a considerable amount of editing, but only to the extent of transforming the airlines to properly laid out traces. The logic should be intact from the schematic. Obviously this is the great advantage to using a CAD system: it offers a much higher degree of accuracy than manual methods. The editing process consists of moving airlines to the desired layers, changing line widths, and inserting and moving vertices. Ground planes are drawn as closed line segments, and then the corresponding airlines are deleted.

After the physical layout is complete, or at any time between editing sessions, it can be compared to the original schematic using the COMNODE utility. This program compares the nodes of the two files and produces a report of the differences.

AUTOTOOLS

The basic RGRAPH package provides the front and back ends of an end-to-end PCB design system. AUTOTOOLS, the autorouter package, is available from the company as an option. It provides an automated means of getting from the physical parts layout—with the airline conductors as input—to a nearly complete board layout, ready for final modification before plotting. Like RGRAPH, AUTOTOOLS is a system of programs—a batch mode router rather than an interactive one. It does not produce a display on the graphics monitor, although it does post quite a few progress messages on the system monitor.

Written in FORTRAN, AUTOTOOLS was originally developed on a mainframe and ported to the microcomputer environment. This heritage reveals itself in subtle ways, such as the need to limit file names to six characters, to avoid overwriting files that differ only in the last two characters of the file name.

An RGRAPH database that is to be autorouted must follow the layer conventions listed in table 1. The input database is an artwork database with components and airlines placed, that has been saved with all levels of nesting enabled. The designer can leave as much or as little to the autorouter as desired. AUTOTOOLS routes airlines on layer 32 and places routed traces on layers 21 through 30 as specified. Traces can be preplaced on layers 21 through 30 if desired.

Operating in its batch mode, the AUTOTOOLS user interface resembles that of RCAP. When AUTOTOOLS is invoked, it prompts the user as to whether or not the existing command file should be executed. If the answer is affirmative, no further input is required; if it is ignored, the main menu is displayed. At this point, a new command file can be built or the routing process can be executed in steps. Because even a moderately dense design can take several hours to route, most designers build files for unattended execution.

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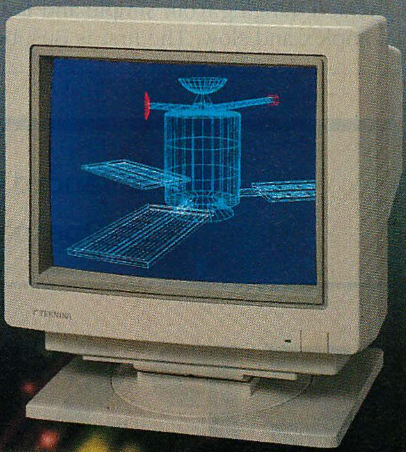

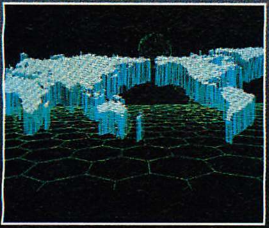

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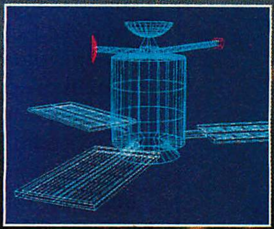
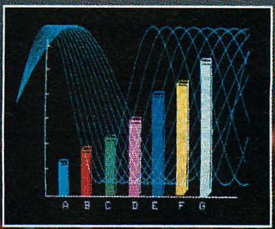


EGA



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The PCB designer can control the autorouter's operation by specifying various parameters. AUTOTOOLS prompts for these parameters, offering default values, when a new command file is built. The first parameter requested is the number of board layers. AUTOTOOLS offers a default of two, a component side and a solder side (layers 21 and 30). Layers can be paired arbitrarily.

The second parameter is the routing algorithm(s)—three are implemented, ranging from simple and fast to complex and slow. The first is Bus, best suited for memory array routing. Bus is the fastest because of its limited search pattern: it can route only layer pairs and does not use vias. This algorithm is not likely to produce a high route percentage on any but the simplest of boards. The second algorithm, Strategy, tends to establish runners in the direction specified and to make connections to that net. Strategy will not route all connections, although it will complete a higher percentage than Bus. It does use vias, conservatively, and attempts not to block route channels.

Exhaustive, the third routing algorithm, uses an unlimited search pattern. This algorithm attempts to route every unrouted net submitted to it, makes extensive use of vias, and blocks routing channels. Exhaustive generally produces a higher route percentage than the two simpler algorithms. Because AUTOTOOLS is not a rip-up-and-retry router, any or all of the algorithms can be applied in any desired order. If the router is instructed to apply all three algorithms in a single session, the order in which they are applied is Bus, followed by Strategy, followed by Exhaustive.

After the routing algorithms are selected, AUTOTOOLS prompts for design rule parameters. The user has control over eight of these: bus route direction, number of layers to route, grid spacing, minimum spacing, width of trace, use of vias, the shape to use for vias, and use of via optimization. The final entry is the selection of nets to route. The submenu for this selection provides three choices: all nets, include specific nets, and exclude specific nets.

Finally, before the router is released, AUTOTOOLS presents a summary of all parameters specified, and offers the operator the opportunity to return to the algorithm selection menu or to proceed with the route.

The recommended technique in using AUTOTOOLS is to build a command file, rather than to execute the program one step at a time. Specifying the various design parameters builds the command file if that option is selected when AUTOTOOLS is first invoked. When the summary screen is displayed and the prompt answered, AUTOTOOLS redisplays the main menu and begins execution of the batch command file when E (exit) is selected.

The command file need not be limited to a single database or to a single routing session. Additional databases can be specified, or additional iterations of the original database can be specified, simply by repeating the sequence of menu selections.

As noted, AUTOTOOLS is actually a batch file that invokes a series of six programs in sequence. Each program returns a value that is tested with the "IF ERRORLEVEL..." syntax of the DOS batch language. Depending upon the error levels returned, AUTOTOOLS can retry various programs, proceed through the complete routing process, or simply terminate without attempting the route.

The first AUTOTOOLS program, SR2, checks the CONFIG.SYS file to determine whether a sufficient number of files can be opened. The second pro-

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gram, SR0, explodes the database file, and creates several intermediate macro files used by the actual router. They are erased when the route is completed successfully, but may remain if the route is not successful. SR0 also establishes a new origin for the database to facilitate the routing process.

PW_MAIN, the third program, is the actual router. It contains all the routing algorithms and consumes most of the time that elapses in a route. The two programs T03C and T03H combine various intermediate files, restore the proper offsets to the database, and convert the database to the form required by the last step. The final program, SR1, converts the routed database back to the RGRAPH format. The result is a database (a .DBF file) that can be displayed and plotted by RGRAPH, and stored as the file specified as the new database file. This file contains the routed nets on layers 21 through 30 as specified, with unrouted nets remaining on layer 32.

Although AUTOTOOLS is not interactive to the point of displaying the routing process on the graphics monitor or of accepting user input during the routing process, it does echo commands and status messages to the screen. Commands are echoed along with the date and time when the command begins. Status messages are echoed at the end of an activity and typically summarize the current activity, the number of nets and connections routed by the activity, and the percentage of nets and connections routed up to that point. During the actual routing, each net is listed by its alias as it is routed, followed by the number of connections just routed or by a message announcing that the routing of the net is complete.

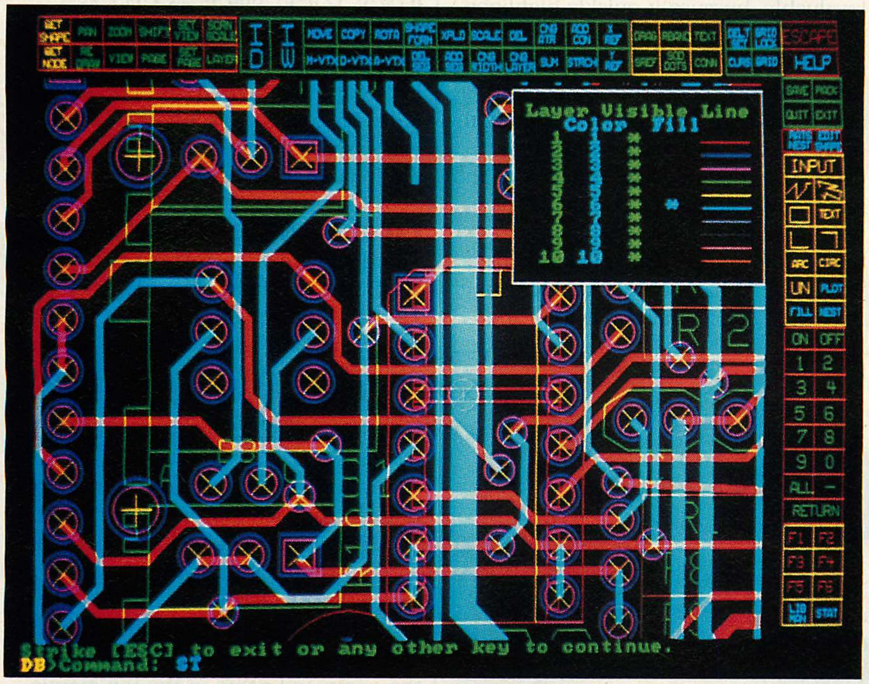
Commands and summary status messages also are echoed to a log file, so that a summary of the entire routing process can be reviewed after the route is completed. Again, commands are recorded in the log file with the dates and times they were invoked by the batch file. The log file does not include the detailed listing of connections routed by net, and it is one of the files affected by the six-character limitation on file names. If seven- or eight-character file names are used for the autorouter output files, a log file could be overwritten, because the output file name is truncated to six characters to form the log file name.

Both the screen display and the log file contain messages that are not explained in the manual. These messages seem to indicate the current subprogram that is running, but the documentation does not provide for correlating the routine names with a particular function in the program. To the experienced RGRAPH user, these messages may provide useful information, but the new user is left uninformed.

The AUTOTOOLS distribution diskettes include a test circuit consisting of 53 ICs, 666 pads, and 177 nets on a board that is 11.9 inches wide by 7.9 inches long. The physical circuit layout database is 15KB, and the associated parts library is 61KB. Using all three routing algorithms and the default design rule parameters, AUTOTOOLS routed 173 nets and 660 connections in 3 hours 19 minutes on a 6-MHz AT. The resultant database was 57KB.

Only two problems were noted while running AUTOTOOLS. The first was an embedded call to C:PW_MAIN, rather than a call to PW_MAIN on the default disk. Most users would not experience a problem with this arrangement, because relatively few install a second hard-disk drive. (Nevertheless, Aptos is removing the drive designator from the call in its next release.)

PHOTO 1: *Sample RGRAPH Screen*



The router does not generate the 45-degree angles (like those shown in this screen) in the traces, but these can be added manually in the RGRAPH editor.

The second problem turned out to be a matter of insufficient disk space on the test system. For the test circuit above, the program would explode the database and build the intermediate router files, but would terminate partway through the route. Freeing up sufficient space solved the problem, but this did highlight the autorouter's need for large amounts of disk space. The circuit mentioned above requires well in excess of 1MB for intermediate files. How much more is not evident, because the only kind of warning issued by the program is the estimated number of blocks required for the file PWVCORE. The program estimates 998 blocks for the test circuit, at 1KB per block. The program does not estimate the space required for the intermediate router files, but they are not nearly as large as PWVCORE. Free disk space equal to 150-percent of the estimated PWVCORE file probably would be adequate, but it is difficult to arrive at a rule, because the program erases all the temporary files at the end of a routing session.

Also note that the design rule parameters selected by the user affect not only the quality of the final board layout, but the speed of operation and the resources required. For example, routing the test circuit described above using four layers increased the estimated number of PWVCORE blocks from 998 to 1,658 and the total elapsed time to 20 hours 58 minutes. In fact, using this set of parameters, the router routed only 149 nets of the 177 total and 607 of 666 total connections.

The AUTOTOOLS interface is teletype-like, scrolling off the screen as the program progresses through the route. The manufacturer says that a graphics display of the route is not provided because it would slow the process even more and because most routes probably will be run unattended in off-hours. This also permits the router to be run without an expensive graphics display adapter and monitor. However, Aptos would do well to provide a stationary status screen, similar to the RGRAPH status summary screen, that would display both a summary of the current activity and the history of the route.

The use of AUTOTOOLS, or of any autorouter, does not reduce the need for skill in PCB design. AUTOTOOLS handles tedious tasks, but the designer is allowed, and expected, to control the design process. Indeed, Aptos recommends that most boards be routed in steps and under control of the designer, rather than simply being submitted to AUTOTOOLS for a single routing session.

AUTOTOOLS is optimized to a 50-mil grid, but grid sizes that are factors of 50 (25, 10, and 5 mils) can be specified. The program does not allow subgrids or offsets in a single session, although the status messages displayed during routing indicate that the mainframe predecessor may have permitted subgrids. Aptos recommends that boards requiring subgrids first be routed with the 50-mil grid, then rerouted using the smaller grid. All traces are routed and centered on the grid.

The current release of AUTOTOOLS is limited to 90-degree turns and T-junctions (even though the literature is illustrated with boards laid out with 45-degree turns—see photo 1). This limitation is a result of the operation of the routines that search the space in the vicinity of a turn or connection. Aptos currently is developing routines for specifying 45-degree turns and Y-junctions. These are planned for inclusion in a future release.

Finally, like RGRAPH, AUTOTOOLS is copy protected. However, instead of using a key-disk scheme like the one used with RGRAPH, AUTOTOOLS has a security device attached to the parallel port. No problems were noted with the use of this device.

PCB ARTWORK

The final product of a PCB design system is artwork for the production of circuit boards. Plotting circuit board artwork is a critical process compared to other fields, such as architecture, in which plots are read by humans, or CAM (computer-aided manufacturing), where a database can be transformed directly into commands to computer numerical control (CNC) machines. The optical reproduction steps that follow require an extremely high-quality plot. To this end, RGRAPH supports two types of final output devices: pen plotters and the Gerber photoplotter.

Pen plots are created from within RGRAPH using the PL (plot) command. This command is designed to accommodate composite plots showing several or all layers of a database on a single plot, or the plots of single layers for photographic reproduction as masters. The program prompts for the scale of the plot, the layers to be plotted, the plot window, the media size, the plotter margin, whether to send the output directly to the plotter or to a disk file for off-line plotting, and whether to pause for pen changes between layers.

Plotting on the Gerber photoplotter is accomplished with the use of a battery of interface programs executed outside of RGRAPH. INTER17 reads the database created by RGRAPH and explodes the shapes, including nested data, into a single level of primitive entities. The program reads the design database, the libraries referenced in the

database, and a set of font files to create an output file. SETGER creates a file of commands for plotter set up, producing a .FIG file as its output. GERPLOT reads the files produced by INTER17 and SETGER and produces a file in the format required by the photoplotter. SHOWGER displays error messages generated by GERPLOT.

The output of GERPLOT can be checked in RGRAPH using the VIEWGER program. VIEWGER generates a macro file that can be executed in a new database. Under control of the macro file, RGRAPH simulates the operation of the photoplotter. This utility proves to be invaluable, because it quickly highlights an improper set-up.

The RSIM utility processes a schematic database and extracts the information required to simulate the operation of the circuit with a logic simulator. (The Aptos documentation mentions the RLOG logic simulator, but the package was unavailable for review.) Conversations with Aptos revealed that it is placing little emphasis on RLOG, preferring instead to concentrate on RGRAPH and AUTOTOOLS. However, RSIM supports several well-known logic simulators—ILOGS, LOGIS, SPICE, and TEGAS. RSIM's operation is comparable to that of RCAP. The menu structures are similar, as are the methods of operation. RSIM processes the schematic database, extracts a node table, and produces a file for input to the selected simulator.

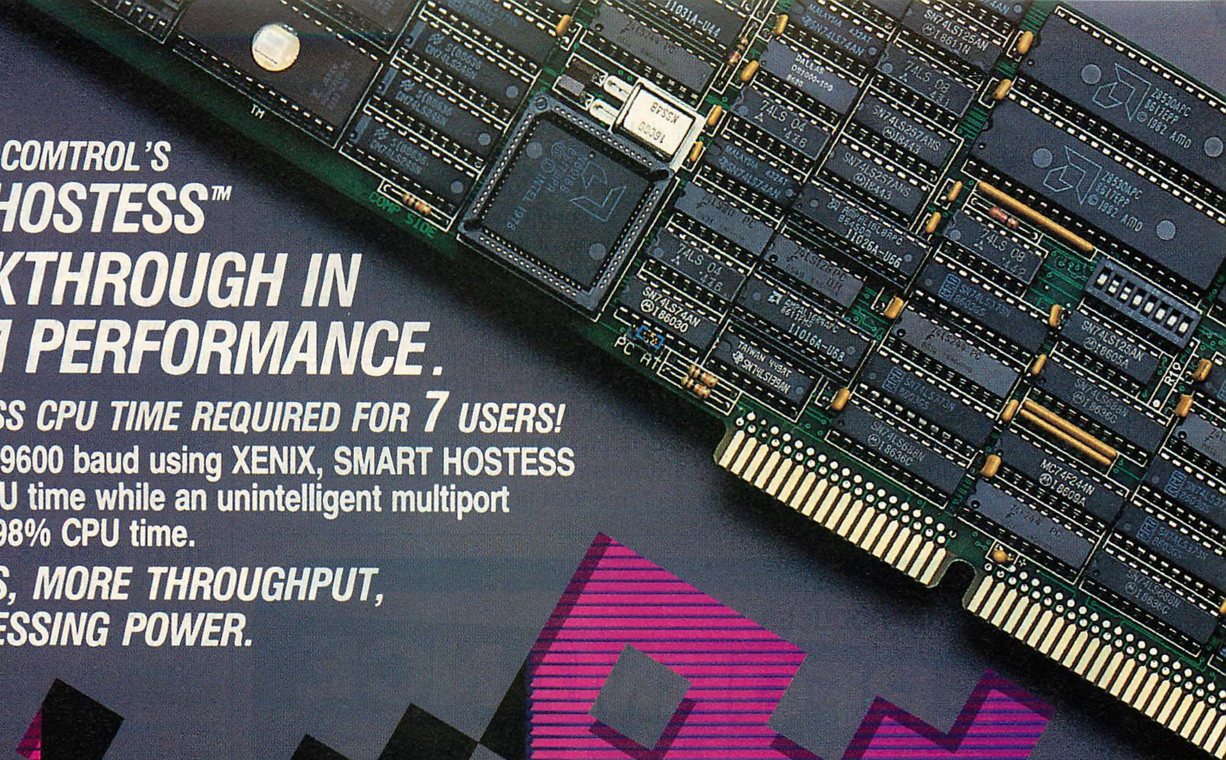
LACKING IN SOME BASICS

The documentation comes packaged in an IBM-style binder and slipcase, about 1½-inches thick, with loose-leaf manual pages, and two additional 8½-by-11-inch pamphlets. The manual appeared to have been published on a laser printer. It includes release notes, an introduction, a tutorial, a reference section, and several appendices. It has no index, but does include a short glossary. The reference section is arranged alphabetically by command name. The command mnemonic, which, admittedly, would be of little help in locating some of the commands, nevertheless accompanies the command name in the top margin.

The tutorial, although short, is well structured, as it leads the user through a small design project. However, it contains a few glaring errors. At one point, the user is advised to name a file with a nine-character file name.

In other respects, the manual falls substantially short of what might reasonably be expected for a package in this price range: At least one command listed in the command chart was missing from the reference section. The manual repeatedly refers to the RLOG logic simulation program, but the RSIM main menu lists the SIMULOG program as the corresponding selection. An introduction covers some general points about the operation of RGRAPH as the editor, but key concepts about the system as a whole are buried in the appendixes, and even that coverage is brief. One appendix dealt with creating menus. In addition, several pages were quite obviously missing from the tutorial—the appendix ended before the menu was complete. Several sections of the manual referred to earlier versions of the program, and one section referred to a utility program that was not supplied with the system.

The AUTOTOOLS documentation is a scant 16 pages. Neither a table of contents nor an index was included. Although the manual is equal to leading the new user through the process of running the program, it provides virtually no guidance for using the package in conjunction with RGRAPH. Such subjects as keep-out areas, keep-in



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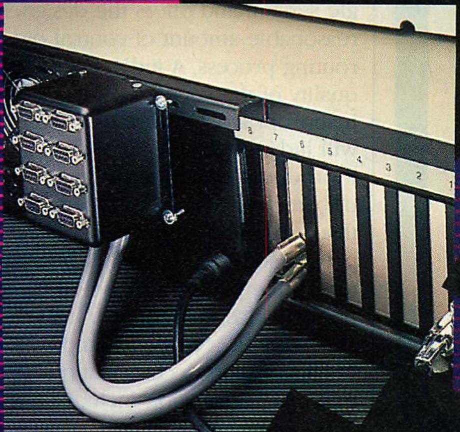

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boundaries, and routing channels are mentioned only briefly—the manual provides no insight as to how the various aspects of the board affect the operation of the router.

The installation of both RGRAPH and AUTOTOOLS is accomplished using the DOS RESTORE program, because several programs take up more space than one diskette. Consequently, both packages must be installed in the same directory from whence they came—C:\RG17. If desired, the program and data files then can be copied to another disk drive. The library files and utilities furnished with RGRAPH can be copied to the hard disk using DOS COPY.

Attention must be paid to the configuration of the system that will be used to run either RGRAPH or AUTOTOOLS. Both require a CONFIG.SYS file with FILES and BUFFERS entries larger than the DOS default. Both also require all the free RAM that DOS will allow. It is likely that any terminate-and-stay-resident programs and loadable device drivers present will reduce the amount of free RAM below the level required.

RGRAPH is set up for a standard hardware configuration. If that configuration is used, the system is ready to go as soon as the hardware is connected and the software is installed on disk. If a nonstandard configuration is required, a new configuration file must be built in a two-step process. First, an ASCII configuration file must be created using a text editor. Several configuration files are included, but may need to be edited. Second, the configuration file must be converted to a binary file using the RSYS.EXE program.

MIXED REVIEWS

As a CAD package at this level, RGRAPH's performance is impressive in some ways, but not in others. Its screen response, for example, is acceptable, but not extremely fast. The program is responsive when drawing new objects, and when retrieving symbols from library files. But when it is highlighting objects, it is less so, because it erases the object and then redraws it. For a part as complex as a microprocessor, this can take several seconds. If the drag mode is on, the program loses its responsiveness when objects are moved. It attempts to redraw the object as it is moved, and in so doing, stops the cursor from following the pointing device. When moving complex objects, the drag mode is best left off.

Although the program takes several seconds to load initially, any remaining disk accesses are quick. Its design databases are small, and its libraries compact. Even though the program must save the database to execute some commands, saving and retrieving go quickly.

RGRAPH exhibits good responsiveness in the execution of macro files. Parts placement is fast, assuming the designer has planned the board layout in advance, and the execution of the airline macro file proceeds as fast as the lines can be drawn.

AUTOTOOLS is capable of achieving a high percentage of completion in a single session and offers the designer a reasonable amount of control over the routing process. A judgment about the quality of the router seems somewhat inappropriate, because each designer will judge the router based on whether it produces routes according to individual preferences. It is sufficient to say that AUTOTOOLS works well—with the proper selection of design rule parameters. If the parameters are off the mark, performance may falter. In this respect, AUTOTOOLS is a classic example of the need for good documentation. With the minimal information included, the new

AUTOTOOLS user is not likely to recognize the effects of the various parameters on performance. The only route will be to try the default set-up first and proceed from there.

RGRAPH is a sound product, but it needs some refinement. Its few rough edges are mostly minor irritants, but they should be corrected. The system is billed as an end-to-end PCB design system, but the basic RGRAPH package does not qualify for that title. The currently optional AUTOTOOLS autorouter is a *must* if the user is to realize full end-to-end design functionality.

Even though both RGRAPH and AUTOTOOLS can stand considerable work in the area of documentation, the vendor may be justified in assuming that a product such as this will be used by skilled circuit designers. Thus, a tutorial on basic circuit design and drafting is not necessary. However, the documentation should cover all aspects of operating the system and those aspects of circuit board layout that affect the performance of the system. Moreover, as with many CAD packages, the real market for microcomputer-based PCB layout systems is not in the large firms that already have a product of this sort running on minicomputers and mainframes, but in the smaller firms that were unable to afford automation prior to the advent of these systems. These potential users are not likely to be experienced computer users. The user can rightfully expect the documentation to be better written and more attractively packaged, especially in a product in this price range. (In addition to its market price, training is offered by Aptos for $250 a day plus expenses, and a video tape is available for $250.)

RGRAPH and AUTOTOOLS demonstrate considerable potential. Used by capable designers, this system should provide high-quality artwork at a considerable savings in layout time. Aptos appears determined to remove limitations in the system, thus offering the promise that RGRAPH will be a formidable competitor in the PCB design arena.

Aptos Systems
10 Victor Square
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408/438-2199
RGRAPH 1.7: $9,950
With Control System Artist 1: $11,350
AUTOTOOLS 1.7: $5,000

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Victor E. Wright is manager of process engineering at Luckett & Farley, a firm located in Louisville, Kentucky.

Drawing Flexible Characters

By applying the principles of vector graphics to character design, users can create type fonts, and scale, move, or rotate graphics characters.

MARK BRIDGER

As the use of the PC's graphics modes has increased, so has the need for flexible and convenient display of characters in graphics modes. By representing characters as a sequence of line segments, rather than a dot matrix, they can be easily scaled, moved, and rotated with standard graphics operations.

The patterns of letters must be stored in such a way that they can be expanded or shrunk to any size. Computer screens and dot-matrix printers reproduce characters from tables that store the actual dot patterns making up a letter. This kind of encoding is not suitable for rescaling or other geometric manipulation. For these purposes, each letter should be stored as a series of directed line segments or vectors. For example, the letter *A* can be drawn as two sloping lines and one horizontal one. Furthermore, these lines can be stored simply by recording their endpoints. Characters created by vector graphics allow a user to annotate plots and other graphics output.

The techniques described here can be adapted to many languages; Turbo Pascal is used in the sample program for this article. Vector character drawing presents some interesting applications of standard Pascal data structures: records, arrays, files, and linked lists.

Each letter can be designed efficiently in a 16-by-16 grid, as shown with the letter *A* in figure 1. The full 16-by-16 grid has not been used in this example. The bottom rows are saved for the descenders on letters such as *g*, while the last columns are used for the spaces between letters. An odd number of columns makes the design of symmetric letters such as *A*, *V*, or *M* easier; therefore, columns 0 through 8 are used routinely for these letters.

The advantage of a 16-by-16 grid is that the row or column of a point can be specified by a number from 0 to 15. Such a number requires only 4 bits, a nibble, or a single hexadecimal digit: 0 to F. If the upper left-hand corner of the grid is the origin, then a point in the fifth column, eleventh row, has the hexadecimal coordinates:

(column,row) = (5, B)

Joining the 2 hexadecimal digits of the coordinates results in the byte:

5BH = 91 (decimal)

When the hexadecimal digits are juxtaposed, the resulting byte is equal to: 16 * (column) + row—in the example, 16 * (5) + 11 = 91. The byte 91 is the ASCII code for the character [.

Using 8-bit ASCII codes, any point in a 16-by-16 grid can be represented by a character. Conversely, it is possible to recover the point that a given character represents by the following procedure: if *N* is the character's ASCII code, then the lower-order nibble, giving the row, is *N* **mod** 16, while the column is given by **div** 16 (or *N* shifted to the right four binary places).

Because a line is determined by two points, any line in a 16-by-16 array can be encoded as two characters: the first represents its initial point, the second its terminal point. A character drawn as a sequence of lines is represented as a string with an even number of characters. The character, *A*, in figure 1 is encoded by the following string:

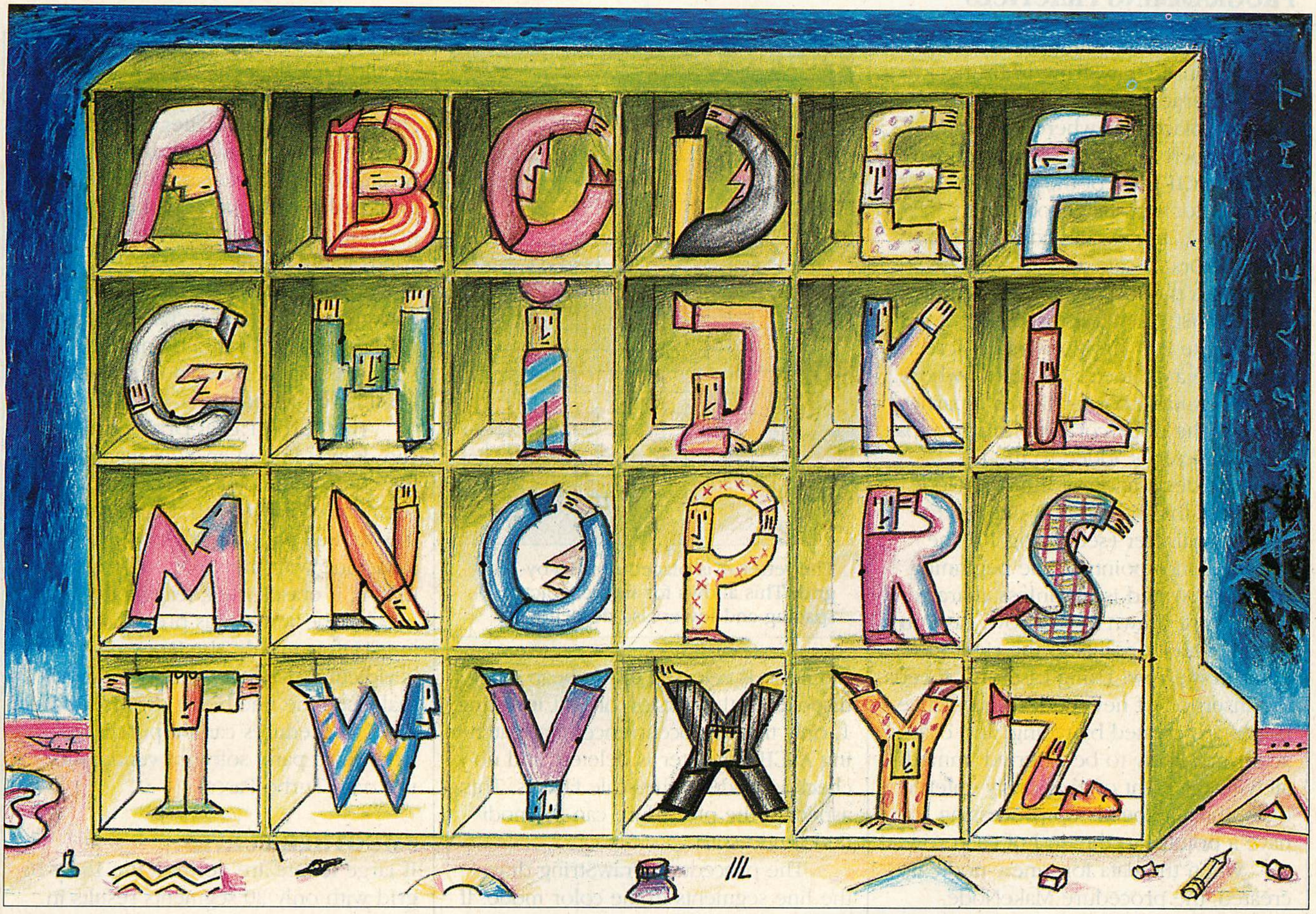


ILLUSTRATION • MACIEK ALBRECHT

chr(10),chr(64),chr(64),
chr(138),chr(37),chr(101)

Strings are declared in Pascal by giving their maximum size, so a limit must be set for the number of line segments making up a character. This is, to a great extent, a matter of aesthetics; drawing a readable % or & seems to take approximately 20 segments, which leads to the following declaration:

```
type CharString = string[40];
     Font = array[33..126] of CharString;
```

A font consists of the characters required by the application, 94 in this case. ASCII character 32, the space, is not included, because it requires no drawing. Typically, the vector definitions for the character set will be loaded from a file.

In listing 1, DRAWCHAR.PAS, only FontArray[65] (the character *A*) has been entered into FontArray in the procedure LoadFonts. The reading of the actual FONTS file into FontArray has been enclosed in a comment because this file is prepared by the user.

It is equally reasonable to record the bytes just as bytes, instead of strings of characters. The advantage of character strings is that many versions of Pascal and other languages provide fast procedures for manipulating strings.

DRAWING THE CHARACTERS

Once a character is encoded, it can be scaled and drawn on the screen quite easily. First, the endpoints of the line segments are retrieved from the encoding, and then the actual line can be drawn using a standard line-drawing procedure, such as Turbo Pascal's Draw. This results in the creation of a character 16-pixels wide and 16-pixels high (counting available spaces in the grid that may not be actually used), located in the upper left hand corner of the screen. The letter, *A*, in figure 1 would be 9-pixels wide and 11-pixels high.

To create an *A* that is 3 times as wide and 2½ times as high, each column coordinate should be multiplied as it is decoded by 3.0, and each row by 2.5. Screen coordinates must be integers, so these products must also be rounded to the nearest integer. The horizontal and vertical scaling factors, 3.0 and 2.5 in this case, are called xScale (or xStretch) and yScale (or yStretch) in listing 1.

Scaling in this way produces a character that is approximately 3 times as wide and 2½ times as high. This is because reals must be rounded to integers, and because length on the graphics screen is not calculated the same way as length in mathematical coordinates. For example, a segment from (0,0) to (8,0) has a mathematical length of 8, but in actuality it is 9-pixels long. This discrepancy should not present any problems to the user.

Once a character's scaled endpoints are determined, moving it to the screen position (x, y), where x = screen column and y = screen row, is accomplished by adding x to each endpoint's column coordinate, and y to each row coordinate. The transformations are as follows:

(col,row) →
(col*xScale, row*yScale) →
(col*xScale+x,row*yScale+y)

The complete decoding and drawing is in procedure DrawString in listing 1.

A character can be drawn to any size and placed anywhere on the screen. Such a drawing is determined by the ASCII code of the character (used to look up its encoding in FontArray), its row and column, and its scale factors, xScale and yScale. This comprises the information for a node in a linked list. Such a list is created for each of the 200 rows on the PC screen. Each time a character is created whose upper left-hand corner lies in a particular row, the node corresponding to that size character is added to the list.

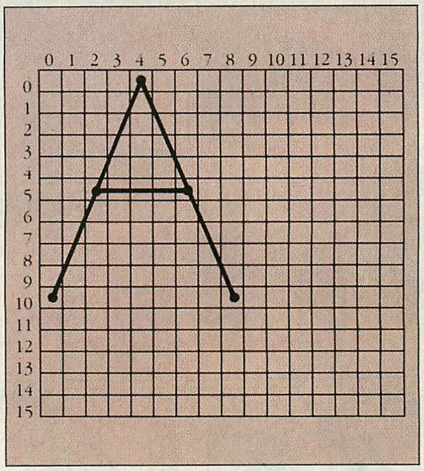
The declaration of the type Node describes the information needed to draw a character (see listing 1). The variable Lines points to the beginning of each row and is **nil** unless characters actually are drawn in that row. LastEntry is either **nil** or points to the right-most entry in the row. Using LastEntry speeds the insertion of new nodes. In practice, nodes are created by typing, and characters are likely to be inserted immediately to the right of previously entered ones; thus, it speeds up processing to have a pointer to the end of each row.

When the data for a new node are created, the procedure MakeNode, which creates the node on the heap, is called. The procedure Edit then goes to the correct row and checks first if the new node is to the right of previous ones, the most likely situation. If it is, then the new node is inserted in the list. If not, then the list is traversed until the correct position is found, and the node is inserted there. When any node is inserted, the procedure DrawString simultaneously draws it on the screen, using the encoded instructions and scaling factors. DrawString uses a pointer to the node to be drawn, as well as an integer designating the row (a byte would suffice for the PC screen, but not for high-resolution output devices).

Provision for the erasure of an entered node must be made. A Boolean variable mode distinguishes between adding and deleting a node: mode = 7 (representing the color white in Turbo Pascal's Draw procedure) is for insertion, and mode = 0 (black) is for deletion. The Edit procedure also can be used to handle deletion.

If mode = 0, the list for the appropriate row is scanned to see if a character is in the desired column; if so, then the scanning continues over characters in that column (several may have been overlaid) to see if one with a matching ASCII number is present. If it is, then the pointers are routed around it, and

FIGURE 1: *Character Example*



The letter *A* is placed in a 16-by-16 grid. This allows for intercharacter spacing and lowercase descenders.

the node is released to the heap using **dispose**. In the version of Edit in listing 1, only the first occurrence of a matching ASCII character is deleted, and no check is made of the scale factors. This aspect of the procedure can be modified if necessary.

The procedure DrawString draws the line segments in the color mode. If a node is being deleted, it is drawn in the background color, erasing it from the screen as well as from the list.

USING THE LISTS

When all of the adding and deleting has been done, the final characters then can be displayed using the procedure WriteOut. Starting with row 0, WriteOut goes to each row and uses DrawString to display all the nodes in that row from left to right. WriteOut can be modified by adding, after the call to DrawString, a call to a plotter's character drawing operation. The plotter manual must be checked to determine the correct relation between the screen and plotter scales in order to maintain the correct proportion of character sizes, but this is fairly straightforward.

In the Turbo Pascal code for the procedures described above, a simple driver program is also included. The user is prompted for the coordinates and scales for a character (always *A*, for simplicity) and whether it is to be added or deleted. The character is then inserted or deleted and the user can repeat or quit. When the user opts to quit, the screen is cleared, and the current content of the lists is displayed. Pressing Enter terminates the program.

Ideally, the drawing of characters should behave the same way typing does in a word processor. The program should provide a cursor, whose size reflects the current scaled size of the characters. Typing a letter should cause the letter to be drawn in the cursor position, with the cursor advancing automatically to the next legal character position. The cursor also should be controllable by the arrow keys. Because the cursor drawing should not affect the background, including characters already drawn, it should be made of line segments that are drawn in an XOR (exclusive or) manner.

The Turbo Pascal Draw procedure can draw a line in an XOR manner if the color parameter is negative. If a line segment is drawn with a negative color, it is XORed with the background. If the same line with the same color is redrawn, it erases itself, leaving the background the way it was previously.

Unfortunately, the Draw procedure is ridiculously slow—the user can actually see the line being drawn. Much faster procedures can be purchased from third party software vendors for use with Turbo Pascal.

SMOOTHER CURVES

If large letters are desired, the 16-by-16 grid with only 20 segments results in rather polygonal-shaped characters. One solution is to allow more segments. This helps somewhat, but the 16-by-16 resolution is still too constraining. Moving to a 256-by-256 grid for each letter, of course, necessitates using two bytes for each segment endpoint. Coupled with more segments, this uses an additional amount of memory.

Some savings can be achieved by drawing segments as much as possible in sequence and recording common endpoints only once. For example, the endpoints of AB BC CD DE EF FG are more efficiently encoded as ABCDEFG. Not every letter can be drawn without repeating certain segments, so the end of a sequence of end-to-end segments has to be signaled within a string. One possible way to do this is to find a row that never appears in the endpoint of any segment in any character. The byte that represents this row can be used as a terminator for a segment sequence within a code string. Another possibility is to use only a 128-by-128 grid. The high bit in each byte can then be used as a termination indicator. This uses the same number of bytes to get only half the resolution in each direction.

Line segments are very simple curves, determined by two points, the endpoints, or control points. A line is the image of first degree polynomials:

$x = a_1*t + b_1$
$y = a_2*t + b_2$

Because a line has zero curvature, there is no flexibility in joining the segments.

If, however, polynomials of higher degree, such as quadratic or cubic, are allowed then considerably more flexibility is evident. The most common choice is to allow a sequence of control points to determine a sequence of cubic arcs. These arcs can actually pass through the points, as in the case of splines, with curvature matching up at the common endpoints, or the arcs can be subjected to bending conditions by the proximity of the points, as in the case of Bezier curves. The actual mathematical rules determining these curves can be found in many standard textbooks. Borland's Turbo Graphix Toolbox contains procedures for fitting cubics in this way; the algorithms are slow, but instructive.

Whether linear, quadratic, cubic or higher power curve fitting is used, the important principle is that the control points, together with the choice of algorithm, completely determines the curve drawn. As a result, any transformations done to the control points cause the curve that they determine to be transformed as well.

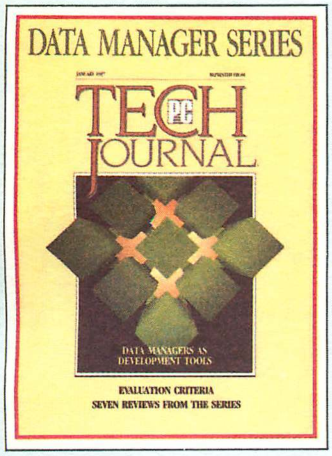
This indicates that characters can be manipulated or transformed simply by applying a transformation to the sequences of control points in the characters' encoding. For example, a character can be rotated by multiplying the coordinates of its control points by some matrix. This is not simply a rotation matrix; it must contain some scaling factors to account for the fact that the number of pixels in the horizontal direction on a screen is usually different from the number in the vertical direction. In any case, once the control points are transformed, these new points are taken as control points, and the appropriate curve-fitting procedure is applied to them, resulting in the drawing of the transformed character.

Complicated solid characters can be defined by giving the curves of their outlines and then using fill algorithms to flesh them out. While these procedures are wasted on the marginal resolution of the computer screen, they can be implemented in the design of type fonts and then reproduced on a laser printer or phototypesetter.

Mark Bridger, Ph.D., is an associate professor of mathematics at Northeastern University and the president of Bridge Software in Upper Newton Falls, Massachusetts.

LISTING 1: DRAWCHAR.PAS

```
program TestWrite;

const
   ScreenHeight = 199;          {rows of screen: 0 ... 199}

type
   Nodepointer = ^Node;
   Node = record
      across : integer;         {position in row}
      ascii  : byte;            {character code}
      xScale,
      yScale :  real;           {scaling factors}
      next   : Nodepointer;     {forward link}
      end;


Var
   Lines, LastEntry: array[0..screenheight] of Nodepointer;
                   {point to first and last entry in row}
   Temp       : Nodepointer;
   xStretch,
   yStretch   : real;
   mode       : byte;           {inserting = 7, deleting = 0}
   ch         : char;
   x, y       : integer;


{ Definitions for the font tables }
Type
   CharString = string[40];
   Font       = array[33..126] of CharString;

Var
   FontArray  : Font;           {Array of strings describing fonts}


procedure LoadFonts;
const
  FontsFilename = 'FONTS';
var
  Fonts: file of Font;
begin
  (****  These are the correct LoadFonts statements:
  assign(Fonts, FontsFilename);
  read(Fonts,FontArray);
  close(Fonts);
  ****)
  {The following is just the letter "A" for demonstration driver.}
  FontArray[65] := #10 + #64 + #64 + #138 + #37 + #101;
end; {LoadFonts}
procedure DrawString(Z: Nodepointer; row: integer; mode: byte);
var I, P, Q: integer;
    Coordinates: CharString;
    x,y: integer;
begin
    I:= 1;
    with Z^ do  begin
      Coordinates:= FontArray[ascii];
      x:= across; y:= row;
      while I < length(Coordinates) do begin
         P:= ord(Coordinates[I]); Q:= ord(Coordinates[I+1]);
         draw(round((P div 16)* xscale + x),round((P mod 16)*yscale+y),
              round((Q div 16)* xscale + x),round((Q mod 16)*yscale+y),
              mode);
         I:= I + 2
      end;  {while}
    end;  {with}
end; {DrawString}


procedure MakeNode(var P: Nodepointer; x:integer; asc :byte;
                                       scx, scy: real);
begin
  new(P);
```



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G. ☐ Hardware Engineering
H. ☐ Programming
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J. ☐ General Management/Administration
K. ☐ None of the Above

4. Which of the following systems activities takes place in your department. (Check all that apply):
A. ☐ Application Development
B. ☐ Programming
C. ☐ Systems Integration/Development
D. ☐ Networking of PC to PC or PC to Mini/Mainframe
E. ☐ None of the Above

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```
  with P^ do begin
    across:= x; ascii:= asc; xScale:= scx; yScale:= scy;
    next:= nil;
    end;
end;

{ Edit: head is Lines[y], last is LastEntry[y]; }
{       P points to the node to be inserted/deleted. }

procedure Edit(var head, last, P: Nodepointer;
                    row: integer; mode: byte);
var place, follower: Nodepointer;
begin
  follower:= head;
  if (head = nil) and (mode = 7)
    then begin  {list is empty, so insert}
      head:= P;
      last:= P;
      DrawString(P, row, mode);
      end
  else if (head = nil) and (mode = 0) then begin end
    else if (P^.across > last^.across) and (mode = 7)
      then begin            {character further to right than others}
        last^.next:= P;
        last:= P;
       DrawString(P, row, mode);
       end
    else if (P^.across > last^.across) and (mode = 0)
      then begin end
      else  {must insert or delete a node in the interior of row}
       begin
         place:= head;
         if (P^.across = place^.across) {correct position}
                     and (mode = 0) {deleting}
           then
             begin
               while (place^.ascii <> P^.ascii)
                     and (place^.next <>  nil)
                 do begin
                   follower:= place;
                   place:= place^.next;
                   end;
               if (place^.ascii = P^.ascii)
                 then begin
                   if follower <> head
                     then follower^.next:= place^.next
                     else head:= place^.next;
                   if last = place then last:=  follower;
                   DrawString(place, row, mode);
                   dispose(place);
                   dispose(P);
                   end
             end  {if deleting}
         else if (P^.across <= place^.across) and (mode = 7)
           then begin
             head:= P;
             P^.next:= place;
             DrawString(P, row, mode);
             end  {if inserting}
           else  {not in first position}
             begin
               while(place <> last)
                     and (P^.across > place^.across) do
                 begin
                   follower:= place;
                   place:= place^.next
                 end; {while}
               if (P^.across = place^.across)  {correct pos.}
                     and (mode = 0)     {deleting}
                 then
                   begin
                     while (place^.ascii <> P^.ascii)
                     and (place^.next <> nil)
                   do begin
                     follower:= place;
```

```
              place:= place^.next;
              end;
          if (place^.ascii = P^.ascii) then begin
              follower^.next:= place^.next;
              if last = place then last:= follower;
              DrawString(place, row, mode);
              dispose(place);
              dispose(P);
              end;
          end  {if deleting}
        else  {inserting}
          begin
            follower^.next:= P;
            P^.next:= place;
            DrawString(P, row, mode);
          end {inserting}
      end  {not in first position}
   end  {interior node}
end;  {Edit}


(**********************************************************************)


procedure WriteOut;
var
    place : nodepointer;
    row   : integer;
begin
  for row := 0 to screenheight do begin
    place := Lines[row];          {point to head of row}
    if place <> nil then          {something in row}
      repeat
        DrawString(place, row, 7);
        place:= place^.next;
      until place = nil
    end; {for}
end; {WriteOut}


procedure InitializeList;
var
    I  : integer;
begin
  For I:= 0 to screenheight do
    begin
      New(Lines[I]);
      Lines[I] := nil;
      New(LastEntry[I]);
      LastEntry[I] := nil;
    end;
end; {InitializeList}
begin

  LoadFonts;
  InitializeList;
  HiRes;

  repeat
    write('Enter x coordinate: ');          readln(x);
    write('Enter y coordinate: ');          readln(y);
    write('Enter horizontal stretch: ');    readln(xstretch);
    write('Enter vertical stretch: ');      readln(ystretch);
    write('Add or delete (a/d) ? ');        readln(ch);
    if ch = 'd' then mode:= 0 else mode:= 7;
    MakeNode(Temp, x, 65, xstretch, ystretch);
    Edit(Lines[y], LastEntry[y], Temp, y, mode);
    write('Draw again (y/n)?');             readln(ch);
  until ch = 'n';

  HiRes;
  WriteOut;
  readln;
  textmode(C80);

end.
```

Reviews and Updates

PCANYWHERE
Dynamic Microprocessor Associates

ZVIEW
Data Management Consultants

COMMAND PLUS 1.1
ESP Software Systems

PCANYWHERE

Dynamic Microprocessor Associates
Worldwide distributor: EKD Computer Corporation
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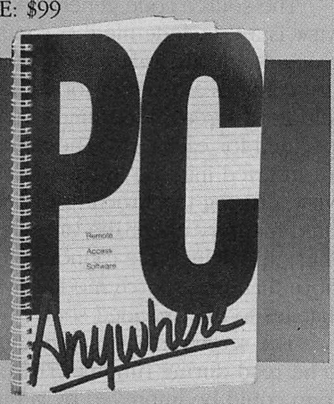


CIRCLE 366 ON READER SERVICE CARD

The idea behind remote computing is fairly straightforward: hook two PCs together using a standard voice-grade telephone link and a pair of modems, then use one of the machines to run programs on the other one. It may be simple in theory, but it is very difficult in practice because software developers have used every trick in the book in order to make their programs run fast and look sharp. One of the results of this chicanery has been that remote computing is difficult to implement.

A remote-access package, PCANYWHERE (written by Dynamic Microprocessor Associates, but distributed by EKD Computer Corporation), has proven to be remarkably successful in using a telephone hook-up to harness the power of programs run on a distant PC. (See "Controlling from Afar," Augie Hansen, April 1986, p. 84 for a comparison of three other remote-access packages.) Uses for such technology are many: customer-support specialists can install PCANYWHERE on users' machines and easily diagnose problems from the home office; office workers can use their office PCs without leaving home; business travelers can update spreadsheets, documents, or databases from their hotel rooms using a portable computer and the hotel phone.

Using PCANYWHERE is fairly simple. The ANYWHERE program is run on the host machine, which must be connected to a telephone line via a standard RS-232 serial port and a modem. The operator of the remote machine then dials the host machine, using ATERM, the supplied communications software for PCs. After a brief log-on dialogue, which can—and should—include password authentication, the host PC returns to the normal DOS prompt. At this point, the remote machine is serving solely as a keyboard and display for the host PC. Every keystroke from the remote machine is passed to the host for processing (just as though it had been typed on the host's keyboard), and the remote screen mirrors everything that happens on the host machine's screen.

During testing, configuring the system was uncomplicated. The two test machines, an IBM PC/XT and a Compaq Plus portable, hooked together without difficulty. Most standard software ran from the remote location: WordPerfect 4.2; Paperback Software International's VP-Planner; Lotus 1-2-3; Ashton-Tate's dBASE III; Symantec's Q&A; Microsoft Macro Assembler; Borland's Turbo Pascal and Turbo BASIC; and many system utilities (including most DOS commands and programs).

Scattered problems occurred with a few memory-resident programs, although most worked remotely, including Borland's SideKick and Turbo Lightning. A screen blanker installed in the host machine worked as expected—it blanked both screens—except that the screen could not be retrieved by pressing the remote's shift keys; it did not come back until the host altered the screen. The resident speller, Whoops! from Cornucopia, did not work from the remote location. Another program that had problems was a public domain keyboard utility (KBFIX2, which provides an enlarged keyboard buffer, an increased keyboard repeat rate, and similar enhancements). When it was loaded on either machine, the remote keyboard could not access the communications program, ATERM. With Quarterdeck's DESQview multitasker, the remote's Alt key did not bring up the DESQview menu, rendering the program unusable. If users have resident software that they must use, they should check with the vendor for compatibility before buying PCANYWHERE.

Considering that all screen and keyboard data must pass through the telephone link, speed is a special concern in remote computing. During testing, the execution speed was quite adequate at 1,200 baud, although it quickly became irritating at lower speeds. To compensate for this disadvantage, PCANYWHERE is reasonably smart about what screen data are passed through the telephone link; for example, after a spreadsheet calculation, only the changed cells are retransmitted. This is true for all programs regardless of how they access the screen; only the changed screen information is sent to the remote.

The PCANYWHERE package includes the ANYWHERE program itself and ATERM, a communications package for the remote PC and various utilities. ATERM is not a general-purpose communications package, but is specifically designed to interface smoothly with ANYWHERE. It offers a conversational mode that permits a dialogue between an operator at the host and an operator at the remote; escape to the local operating system, which allows the user to interrupt a session to run programs on the remote PC; and various options to control printing

generated by host programs (print at host, print at remote, print to spool file). ATERM is fairly easy to use and seems to be quite capable.

The utility programs include ASEND, which performs file transfers between the host and the remote using the XMODEM protocol; ALOGOFF, which terminates a PCANYWHERE session; and ACANCEL, which not only terminates a session, but also disables PCANYWHERE on the host machine, preventing further call-ins until the program is restarted manually on the host machine.

In addition, PCANYWHERE itself can be configured in various ways. It can be set up to require passwords at log-on or to execute a specific DOS command (which can be a batch file) when a password is received. It also can be run in resident mode; when resident, the host computer can be operated normally while waiting for a call. When a call is noted, PCANYWHERE takes over the machine and the session proceeds as usual, except that the caller may be in a program rather than at the DOS prompt after log-on. The company states that this is a strong selling feature frequently requested by consultants.

The PCANYWHERE system operates best when using two PCs with Hayes-compatible modems, and with ATERM running on the remote machine. However, facilities are provided for the use of non-Hayes modems, and the remote can use almost any terminal emulation software. The two machines also can be linked directly via a null modem set-up, eliminating the need for modems; transfer rates of up to 19,200 bits per second (bps) are available, but problems were encountered at speeds above 9,600 bps. Although the two test computers were side by side, intermittent data losses occured at the faster rate.

When using non-PC remotes or PCs using software other than ATERM, some reconfiguration is necessary. The terminal protocol must be specified (VT52, VT100, and dozens of others are supported), and a keyboard reconfiguration program may be needed. In normal use of dumb terminals or software other than ATERM, Esc-key combinations are substituted for the PC's special keys; for example, PCANYWHERE translates Esc-U into the up-arrow keystroke.

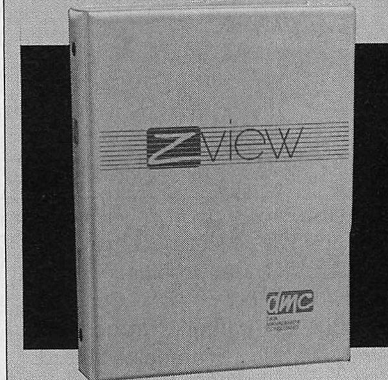
A robust package, PCANYWHERE allows remote access to PCs via a telephone/modem link. It is a fairly easy system to set up and use, and it allows the use of almost all PC software from a distant computer or terminal.

—CHRIS DUNFORD

ZVIEW

Data Management Consultants
5325 Valley View Blvd., Suite 7
Las Vegas, NV 89118
702/798-5910

PRICE: $245



CIRCLE 364 ON READER SERVICE CARD

A combination of screen generator, application generator, and screen-management utility, ZVIEW caters exclusively to the C-language programming environment. After the screens are designed with ZVIEW, they can be modified in a separate utility. Each include file contains the data structure information for an individual screen. The applications developer then can use this include file and ZVIEW's runtime library to collect the data entered.

The screen generator, called ZPAINT, is rather limited compared with other programs of this type on the market. The documentation for ZPAINT is buried in chapters 3 and 4 of the manual. The user can draw a box, display text with specific background and foreground colors, move and copy blocks, and determine the location of data entry fields. The only attributes for the data-entry field entered during the screen-generation process is the protection value: protected, unprotected, or header. A separate program specifies other attributes for data-entry fields, which can be quite bothersome if the screen and fields must be changed frequently.

A separate field-descriptor program, called ZFIELD, allows the user to specify a variety of attributes on a field-by-field basis. The documentation for this program is not in one place, but split between chapters 3 and 5. Attributes include field type, range checking, field-to-field comparison, required or optional fields, field-specific help, security level, and a user-specified, field-exit procedure. The user can specify a separate list of dynamic characteristics at runtime by setting values to global variables, such as help-key values, cursor attributes, user security level, error beeping, and checking on input. Unfortunately, the documentation introduces these attributes in a manner that is not only haphazard, but also very confusing.

The screen generator and the field-descriptor program both require support routines in a directory called \ZSCREENS, which must be a subdirectory in the root directory. (This requirement is described in the installation section of the manual.) If they are not, a "DOS ERROR IS 2" message appears, but no further explanation is available in the manual. In a blatant example of poor design, ZVIEW's procedure for entering field specifications can result in loss of data if the user merely tries to end a field by using Enter instead of the down arrow. Pressing the Enter key clears the screen back to the default values and returns to the first field.

The source code generated by ZVIEW is a C include file that contains a structure tag and a definition. The structure contains a member for each data field for a screen, according to the type specified for each field. The definitions are inserted into the include file by ZVIEW, causing the structure to be allocated memory under the variable name. Thus, the include file cannot be used in more than one source module without changes to the provided source.

The screen image is saved in a file to be read during runtime. The program could be improved by generating an object file or C source code that can be compiled and linked.

ZVIEW supplies a library to display, read, and write the screens and data. Calling the display function from a C program results in the screen file being read from the disk and displayed. A second read function actually collects data from the screen and returns when the screen is exited. A separate function then is called to read the data from the screen into the data structure. A write function writes the data from the structure onto the screen.

A separate library is supplied depending on which compiler is being used. The source code to this library should be provided with ZVIEW, but it is not. Although a list of the supported compilers is not available, reading the conditional compiles in one of their include files seems to indicate that ZVIEW supports the Microsoft, Lattice, DataLight, and Aztec compilers. Some additional utilities are provided, but the documentation introduces them with

the warning, "Enter at your own risk." These can be used to create sound on the PC's speaker, halt the system for a given number of system ticks, or set the cursor to a screen position or size.

Technically, ZVIEW is excellent, allowing the user to build very complex data-entry screens. Mastering the program is largely a matter of trial and error—very little works the first time. The documentation is unacceptable. Pages are out of order, the information is presented haphazardly, appendixes are located in the front, and there is no index or list of error messages returned by the screen generator. The large number of typographical errors indicate that no proofreading or even spell checking was done; even the product name was misspelled in one place. Despite ZVIEW's potential, the presentation is totally inadequate, and the user interface needs drastic improvement.

—STEVE JOHNSON

COMMAND PLUS 1.1

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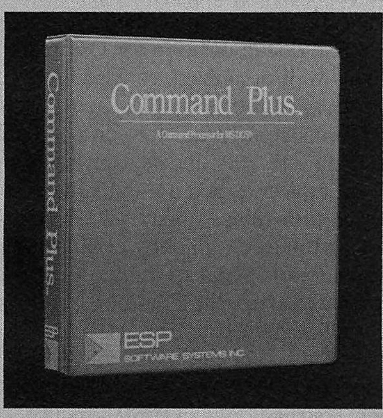
Los Angeles, California 90066
800/992-4377; 213/390-7408

PRICE: $79.95



CIRCLE 365 ON READER SERVICE CARD

Command Plus from ESP Software Systems is a DOS command processor that takes over the main functions of COMMAND.COM: the interpretation of keyboard commands, the execution of batch command files, and the loading and execution of external programs. To these functions, Command Plus brings some of the nicer features found on larger operating systems.

COMPLUS, the primary file, can be installed either as a secondary command processor or, in DOS versions 3.0 and later, as the primary one in place of COMMAND.COM. To set up Command Plus as a secondary processor, the user places COMPLUS.EXE in a directory that is specified by the PATH command, and enters **complus [options]** at the DOS prompt. This causes COMPLUS to take control of command entry. Typing **exit** returns control to COMMAND.COM. COMPLUS is installed as the start-up command processor by the following statement in the CONFIG.SYS file:

shell = [d:][path]complus[.exe] [options]

In this mode, the user cannot return control to COMMAND.COM without first modifying the CONFIG.SYS file and then rebooting the system.

As a COMMAND.COM replacement, COMPLUS handles the internal DOS commands in the same way and provides similar or enhanced services for command-line editing, file-name pattern matching, I/O redirection and piping, the execution of batch files of command scripts, and automatic execution of an AUTOEXEC file on system start-up. COMPLUS offers several additional features that have no counterparts in COMMAND.COM: an enhanced command language for writing batch command scripts, command-history recall, command abbreviation or alias facility, directory stack, command log file, and additional internal commands to display memory and disk space, display the contents of files, move files between directories and search for files through the tree structure. One significant extension of this program is that all COMPLUS commands return a completion code so that other programs or script files can determine the termination status of the command.

The most impressive feature of Command Plus is the interpretive command file processor, SCRIPT. It implements a miniature programming language that provides enhances features, such as the ability to define as many as 15 program variables, branching and looping, expression evaluation and assignment, arithmetic, comparison and Boolean operations, sending text to standard input data, and comment statements. In addition, SCRIPT provides built-in library routines for string manipulation, console I/O, file operations, and access to strings from the DOS environment. To make this a complete and useful tool, SCRIPT also has a debug mode that lets the user see the commands that will run without actually executing them. As an example of SCRIPT's capabilities, the following SCRIPT file allows the user to choose which .c files in the cur-

rent directory to view with the BROWSE command of COMPLUS:

```
FOR %a in (*.c)
BEGIN
   WRITE " view %a ? "
   READ %b
   if (%b = "q") OR (%b = "Q")
      BREAK
   if (%b <> "y") AND (%b <> "Y")
      CONTINUE
   browse %a
END
```

Command scripts that are written in the SCRIPT language are assigned the extension .S, not .BAT. Therefore, if COMMAND.COM is restored as the command interpreter, it can use its original .BAT files without alteration. COMPLUS can execute both .S and .BAT files, but a copy of COMMAND.COM must be loaded in order to run the latter. If several executable files with the same name exist, the order of precedence is .COM, .EXE, .S, .BAT. When COMPLUS is loaded into the system as the primary command processor, it executes the start-up file AUTOEXEC.S.

Because most of an operator's time is spent at the command-entry level, COMPLUS provides a number of features to enhance the keyboard interface. Extensive facilities are available for editing the command line: positioning the cursor, deleting various parts of the command line, inserting characters, recalling previous commands, undoing changes to the command line, and searching for characters. Multiple commands can be issued on one line; the command separator can be specified by an entry in the environment. Any of the last 48 commands can be recalled from a command-history buffer. Aliasing provides a macro capability by allowing the assignment of names to character strings that can be commands. As an example, the name *up* could be assigned to the string **cd ..** to simplify going up one level in directory structure.

COMPLUS goes significantly beyond DOS in its ability to match file name patterns, making command entry for operations that involve multiple files much easier. To the * and ? wild-card characters of DOS, COMPLUS has added a subset of UNIX-like regular expressions that match a range of characters. For example, **copy c:[a-z^t]*.*** copies from the C: drive all files that start with any letter except the letter *t*.

Several other features are significant extensions to the capabilities of COMMAND.COM. The first is the full-screen file viewer, BROWSE, which provides paging, scrolling, easy cursor positioning, and a regular expression searching capability within the file. Another is the LOG facility, which allows the user to maintain a date/time-stamped log file of executed commands. With logging enabled, all commands are automatically placed in the log file as they are executed. When logging is disabled, entries to the log file can be made with the LOG command followed by a parameter string. This string gets placed in the log file.

In addition to providing features unavailable in COMMAND.COM, COMPLUS also enhances some familiar DOS commands, such as DIR, COPY, and DEL. DIR allows the user to display the files in a short or long format, show system and hidden files, display file attributes, and sort directory listings. COPY and DEL can copy or delete multiple files identified by a list of names on the command line, by a range of date/time stamps, or by the aforementioned regular expressions. These commands have options to copy or delete files from subdirectories and to display only the files that can be copied or deleted, without actually performing the operation. COPY also can copy to multiple disks, prompting for a new disk when the target disk is filled.

ESP documentation for Command Plus is well organized, concise in its descriptions, full of examples, and comes with a convenient quick-reference card. According to ESP, updates are free for six months and then a nominal fee is charged for future updates. ESP provides a toll-free number to call for technical support between the hours of 9 a.m. and 5 p.m. (Pacific time).

All of the extra features of Command Plus come at a price: memory usage. COMPLUS occupies 50KB more memory than does COMMAND.COM. The only other complaint that can be lodged against Command Plus is that a copy of COMMAND.COM must be loaded in order to run the batch file. Not only does this procedure cause a slight delay while the original command processor is found and then loaded (COMPLUS searches the directories named in the system PATH to find it), but it also uses up additional memory.

For users who spend a lot of their computing time at the DOS level (outside the realm of applications software) and who believe that their time is money, Command Plus is a wise investment that easily pays for itself.

—JOSEPH KRALOWETZ

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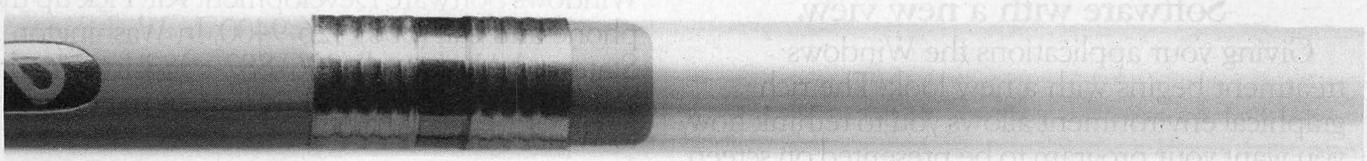

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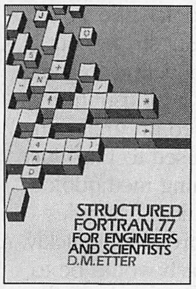
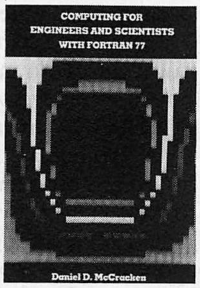
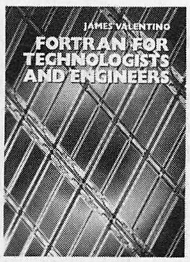
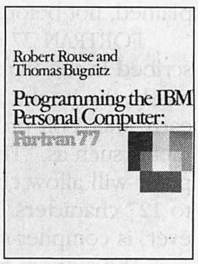
Lingua FORTRAN

FORTRAN, the lingua franca of scientists and engineers, is the subject of four textbooks.









Structured FORTRAN 77 for Engineers and Scientists
D. M. Etter (The Benjamin/Cummings Publishing Company, Inc., 1983) 357 pages; paper, $25.95

Computing for Engineers and Scientists with FORTRAN 77
Daniel D. McCracken (John Wiley & Sons, 1984) 361 pages; paper, $30.75

FORTRAN for Technologists and Engineers
James Valentino (Holt, Rinehart and Winston, 1986) 594 pages; paper, $29.00

Programming for the IBM Personal Computer: FORTRAN 77
Robert A. Rouse and Thomas L. Bugnitz (Holt, Rinehart and Winston, 1983) 240 pages, paper, $42.75

The four books on FORTRAN 77 reviewed here span the spectrum from inspired to mediocre. The first two cover the subject in different but equally competent ways; these books also offer pedagogically superior material. The third is an adequate text with many excellent examples. The fourth is simply not in the same league as the others, having been keyed to a FORTRAN compiler that is now obsolete. (For a comparison of seven FORTRAN 77 compilers, see "FORTRAN Perspectives," John Voglewede, this issue, p. 92.)

D. M. Etter, the author of *Structured FORTRAN 77 for Engineers and Scientists*, succeeds in familiarizing his readers with the capabilities of computers, FORTRAN 77 fundamentals, and good problem-solving techniques. The book abounds with good example applications; some are solved, the rest are exercises. Solutions to selected problems appear in an appendix.

The book contains insightful style and technique guides, debugging aids, and programming hints. Structured programming is examined, with both flowcharts and pseudocode used as development tools. Later examples stress modularity and step-wise refinement.

After an introduction to computing, the author addresses arithmetic computations, including implicit and explicit typing, arithmetic hierarchy, and intrinsic functions. He continues with I/O, covering list-directed, formatted, and file I/O (important, yet often omitted).

Chapter 4 presents FORTRAN control structures. The use of an artificial WHILE. . .DO construct made from an IF. . .THEN. . .ENDIF and a GOTO is stressed. The use of older FORTRAN constructs, such as the arithmetic IF and the computed GOTO is discouraged. The next two chapters contain good discussions of DO loop structures and arrays. Excellent descriptions of single- and multidimensional arrays are given.

Chapter 7 covers subprograms, including an explanation of intrinsic and external functions, subroutines, and COMMON blocks and BLOCK DATA subprograms. A program to introduce interference plots on a printer serves as an excellent primer on character strings —the focus of chapter 8.

The final chapter addresses topics usually omitted or superficially treated in introductory texts. Double-precision and complex arithmetic, logical variables, and IMPLICIT, PARAMETER, and EQUIVALENCE statements are introduced in concise sections. Additional topics are variable formatting and less-frequently used subprogram statements, such as SAVE, INTRINSIC, EXTERNAL, and ENTRY. The book concludes by completing the treatment of file I/O.

Excellent in content and presentation style, the book offers a complete view of FORTRAN 77. It is blessed with the author's well-written, well-edited prose. Constant attention to programming style and debugging techniques make it stand out.

TEACHING ASSISTANT

Daniel D. McCracken, the author of *Computing for Engineers and Scientists with FORTRAN 77*, shares his many years of teaching experience in an insightful manner. He presents the material in a logical, well-structured fashion by anticipating and coping with questions as they naturally arise.

The book has four goals: to promote programming competence, to reveal the computer's powers and its limitations, to establish effective communication with programming experts, and to use a computer without resorting to conventional programming.

The author places great emphasis on programming style and structure throughout the text. The entire fifth chapter is devoted to program development and testing. The concepts of top-down design, step-wise refinement, and modularization are explained and demonstrated in detail through examples. In a novel approach, the author presents a complete root-solving program with known syntax and logic errors. The student is encouraged to enter the program and gain firsthand experience with debugging techniques.

Following an excellent introduction, the author discusses assignment statements and control structures. Standard FORTRAN 77 control structures and simulations of WHILE. . .DO and REPEAT. . .UNTIL structures are given. The fourth chapter introduces functions and subroutines; the ninth reinforces them. Subroutine libraries, such as that produced by IMSL (International Math Subroutine Library), are mentioned.

Formatted I/O, DO statements, and arrays are covered individually. Double-precision, complex, logical, and character variables are viewed in chapter 8.

The final chapter, "Nonprocedural Approaches to Application Development," is most intriguing. The author describes several software packages (such as Microsoft muMATH, information-retrieval systems, and text formatting programs) as alternatives to traditional programming. Sample on-line sessions illustrate the utility of this problem-solving approach.

The book contains many excellent examples and exercises of increasing complexity. Many are answered at the end of the book. The only potential weakness in the book is its failure to discuss the entire language. Unlike the first book, file I/O is not addressed.

Teaching by example, the author considers programming as an art form, with its nuances of style. For this reason, and for its overall effectiveness as an introduction to FORTRAN 77, this book is highly recommended.

OPULENT EXAMPLES

Like the first two books, *FORTRAN for Technologists and Engineers* supports programming classes for science and engineering students. In it, the author, James Valentino, seeks to present the language, to develop good programming habits, and to apply practical problem-solving techniques; he succeeds, with a few shortcomings.

A general discussion of computers is followed by an introduction to the language. The author examines how to write and run an entire FORTRAN program; both batch and interactive processing are discussed.

The book's clear layout and good examples aid in the discussion of formatted I/O in chapter 4. List directed and file I/O are not discussed—a somewhat serious deficiency.

The next two chapters discuss arithmetic assignment statements and exponential notation. The outstanding examples and real-world problems are drawn from a variety of disciplines. Those in chapter 6, for instance, involve fluid dynamics, orbital mechanics, and AC (alternating current) circuit analysis.

Chapters 7 and 8 involve control structures. Each FORTRAN control structure is explained in detail and featured in examples. The WHILE. . .DO and DO. . .UNTIL constructs of WATCOM WATFIV-S are given special emphasis.

One-, two-, and three-dimensional arrays are studied in the next two chapters. Examples use DO loops and implied DO loops in the input, processing, and output of data in arrays. Statement functions, functions, and subroutines share a chapter with COMMON blocks. Stressing structured programming techniques, the author gives examples of modular programs.

Emphasizing scientific and engineering applications, the author devotes a chapter to complex arithmetic. The mathematics involved is briefly reviewed and its use in FORTRAN is explained. An example program determines the effective magnitude and phase angle of the current in an AC LRC (inductor-resistor-capacitor) circuit.

The final chapter covers additional features of the language, such as character data, logical variables, and double-precision variables. The first appendix lists FORTRAN library functions; the second covers programming on the IBM PC with the outdated IBM PC Professional FORTRAN compiler.

In general, this book makes a fine introductory text applicable for both classroom and individual use. The book's strongest feature is its selection of examples, offering over 350 solved problems and exercises. The topic areas include electrical and mechanical engineering, mathematics, and business.

The book does have some weak points. It could be improved by including discussions of the complete language. Important FORTRAN features, such as file I/O and the BLOCK DATA subprogram, are omitted. The author should have concentrated on the language standard instead of individual implementations such as WATFIV-S. The book is also limited by its failure to introduce pseudocode as an algorithm development tool, and by several typographical errors within the figures.

Overall, the book's strengths outweigh its weaknesses. It is recommended as an introductory textbook.

LIMITED APPEAL

The fourth book, *Programming the IBM Personal Computer: FORTRAN 77* by Robert A. Rouse and Thomas L. Bugnitz, is disappointing and frustrating. The two authors rely upon the early Microsoft FORTRAN compiler, which proves to be a mistake for two reasons. First, the early version of that compiler did not comply with the improved standard that was adopted in 1978 by the American National Standards Institute and the International Standards Organization. Second, the compiler has changed over time to include more language features. With other compilers available that comply with the standard, the authors should have been more selective—especially with "FORTRAN 77" used prominently in the book's title.

The book starts out strong, but quickly tires. An introduction to computers is followed by an illustration of FORTRAN 77 structured programming style. Pseudocode is used to introduce structured programming methodology. The chapter on style uses examples aimed at producing programs quickly. A more effective approach would be to give examples as the language is explained, not before.

FORTRAN 77 data types are described in the third chapter. Unfortunately, the book's alignment with the early Microsoft product results in statements such as, "The IBM Personal Computer will allow character strings of up to 127 characters." This limitation, however, is compiler-specific.

The authors go on to discuss assignment statements, data manipulation, and basic I/O techniques. Chapter 5 emphasizes sequential, formatted files. Control structures are developed in the next two chapters. The first treats IF statements. A FORTRAN 77 simulation of DO. . .WHILE and REPEAT. . .UNTIL constructs is given in the second.

The next chapter introduces program modularization. Here, functions, statement functions, and subroutines are explained. Chapter 9 addresses direct-access, unformatted files along with advanced I/O features. The book concludes with a brief treatment of logical variables and subprogram libraries. Several routines are provided, such as a polynomial differentiation subroutine.

This book is not recommended. It is incomplete, too brief, and too compiler-specific to be of use as a textbook on FORTRAN 77. The other three books, however, are excellent guides to the language. D. M. Etter's *Structured FORTRAN 77 for Engineers and Scientists* stands out from the other two because it covers the complete language and does so with style.

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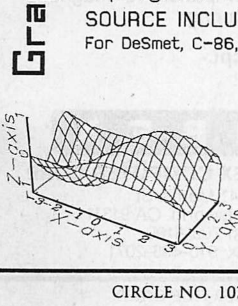

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Framing Knowledge

Artificial intelligence can be used to instill common sense into computers by organizing knowledge into a particular frame of reference.

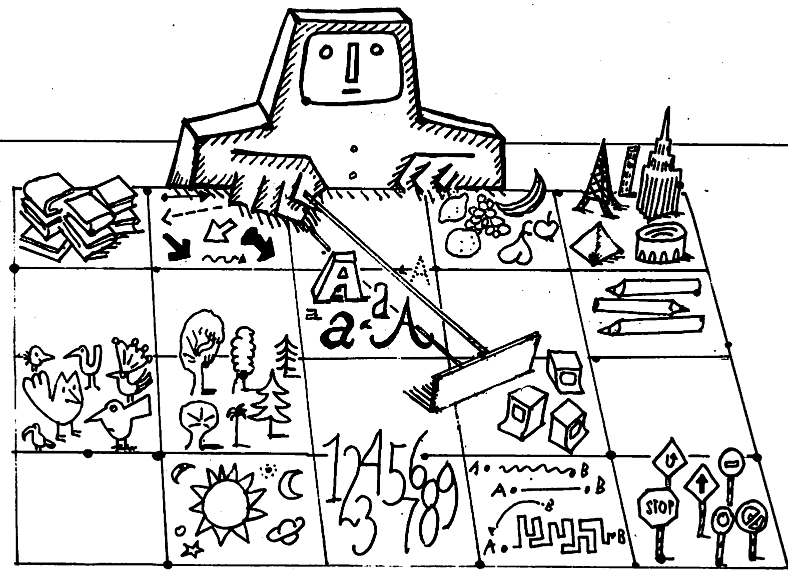


ILLUSTRATION • MACIEK ALBRECHT

Consider the following conversation:
"Can you come for dinner next Saturday?"
"I'm not sure. I will have to try to get a sitter."
"Maybe Mary can do it."
"Is there anything I can bring?"
"Maybe some wine."

The speakers convey a substantial amount of information that is not explicitly addressed. For example, location of the dinner at the home of the first speaker is implied. Presumably, "to get a sitter" means the second speaker will have to ask a babysitter to take care of his children for next Saturday night so that he can attend the dinner. The "it" that Mary may be able to do is the babysitting task. Asking to bring anything is customary when being invited to someone's house for dinner, and "wine" is the customary response. A larger gift, such as a new car, would not even be considered.

How did this conversation manage to convey so much information so quickly and with so little qualification? The answer has to do with the base of knowledge that the two speakers share. Because of common experiences involving hosting guests, giving dinner parties, and bringing up children, the speakers can communicate efficiently with very sketchy information.

Put succinctly, human beings are able to use common sense. Drawing from previous experience with the same or similar situations, people rely on standard stereotypes to suggest interpretations and appropriate behavior. People can adapt in order to deal with shifting truths and changing facts.

Computers, on the other hand, traditionally have manipulated rigidly held truths with deductions based on sound mathematical reasoning. Artificial intelligence, however, uses certain techniques to model common sense and stereotypical knowledge. These techniques direct the search for relevant information, cutting down the sheer bulk of knowledge that must be considered in order to draw appropriate conclusions.

Much work in knowledge representation within the AI community focuses on the concept of *frames*. Originally proposed by Marvin Minsky in 1975, this concept has initiated a large body of research.

A frame provides a structure, or framework, in which to interpret information in terms of previous experience. It is a form of representing knowledge about objects and events that categorizes what is typical about a context. A frame includes information about

- what entities (people, objects, and locations) are involved;
- key questions to be answered;
- how to get answers to the questions;
- what default answers can be assumed if no other information is available;
- what other frames are related.

Frames represent one method of hierarchically organizing knowledge to reduce the amount of data that must be checked for relevance. They are used to organize knowledge in a way that directs attention toward important details. They also provide a context that governs expectations about what questions need to be answered.

Information about the presence of certain people or objects can suggest exploration of a specific frame. This in turn can focus a search for the other players typically involved in the frame. Fitting this information into the frame helps to reinforce the frame's relevance. Having identified the players, the frame then provides a series of questions to determine pertinent facts. The frame would suggest procedures to help find the answers to these questions.

A very important contribution of the frame is the assignment of default values. Managing these default values—and revising assumptions when actual information becomes available—is a key aspect of a frame's utility. Research in psychology suggests that when presented with a situation, people assign concrete interpretations rather than leaving the concepts abstract. These default images are refined as actual details are uncovered. People draw conclusions based on the default values. Related experiences can be invoked in the context of the default assumptions.

As an example, the sentence, "The baby played with the toy," conjures up a mental image of a particular baby and a specific type of toy. The baby's age and the kind of toy would depend on your previous associations with babies. The toy undoubtedly would be small and lightweight, perhaps a rattle or small ball; it certainly would not be a

sharp object. These kinds of assumed properties can subtly direct inferences.

A frame can be a special instance of another more general frame. This allows one frame to inherit the characteristics of another frame, augmented by more specialized properties. A dinner-party frame, for example, is a specific instance of both a dinner frame and an entertainment-at-home frame.

The dialogue presented at the beginning of this column involves several different frames. A dinner-party frame would define that a dinner party includes a host and one or more guests. Because the host is inviting people to his or her home, a visitors-to-home frame also is relevant. Inviting guests with children carries a default assumption that the children are not invited, thereby triggering a babysitter frame.

These frames could have the following structures:

Dinner-party frame (specialized instance of dinner and visitors-at-home frames).
Players: Host, one or more guests
Location: Home of host; ask for directions to home if not known
Invitation: Initiated by host
Scope of invitation: Default to immediate recipient and spouse
Time: Date and time for visit; default to 8 p.m. on weekend
To bring: Gift appropriate to dinner; default to wine or flowers

Babysitting frame (specialized instance of family and contract services frames).
Players: Parents, children, babysitter
Babysitter: Person over 12 years old
Payment: Default to $3 per hour
Motivation: Children cannot be left alone at home
Location: Home of parents
Action: Parents leave house; children stay with babysitter

Each slot in a frame defines a property to be discovered and a procedure to find it when not explicitly provided. This procedure can be specified directly in a programming language such as LISP, or it can be described through a set of constraints using Prolog or mathematical logic.

Frames have been used as the top-level organization for knowledge in expert systems. The system is responsible for determining which frames are relevant for a given context and evaluating the procedures attached to frame slots to drive the reasoning and problem-solving within the system.

Many variations of the frames approach have been proposed in the AI literature and have been applied to a variety of problems. For example, in natural language understanding, frames provide one way to deal with anaphoric references (such as the use of *it*) and with indirect answers (to avoid the computer answering "Yes" in response to the question "Do you know what time it is?"). In image understanding and computer vision, frames have been used to deal with reasoning about any objects that are only partially visible ("Does that look like another door back there?"). For document recognition systems, frames provide a way to recover from partially readable information, based on context. In computer-aided fault-diagnosis, frames can be used in developing and substantiating a model of a potential problem.

The jury is still out about whether frame-based approaches are still too rigid for reasoning about imprecise and evolving information. In a future column, we will cover recent work on knowledge representation based on neural networks that are patterned after the human brain.

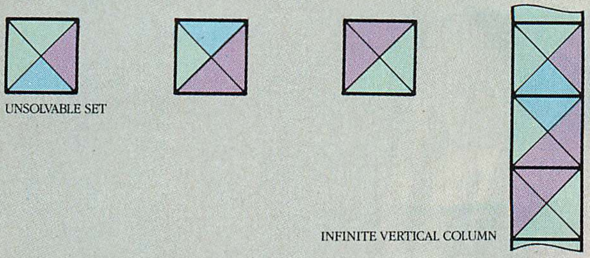
Richard Schwartz, Ph.D., and Robert Shostak, Ph.D., are vice presidents of software development and cofounders of Ansa Software.

DOMINOES SOLUTION

Our last Applied AI column ("What Computers Cannot Do," March 1987, p. 177) presented two dominoes problems that were left to be solved by the reader. The answers to these problems are provided below.

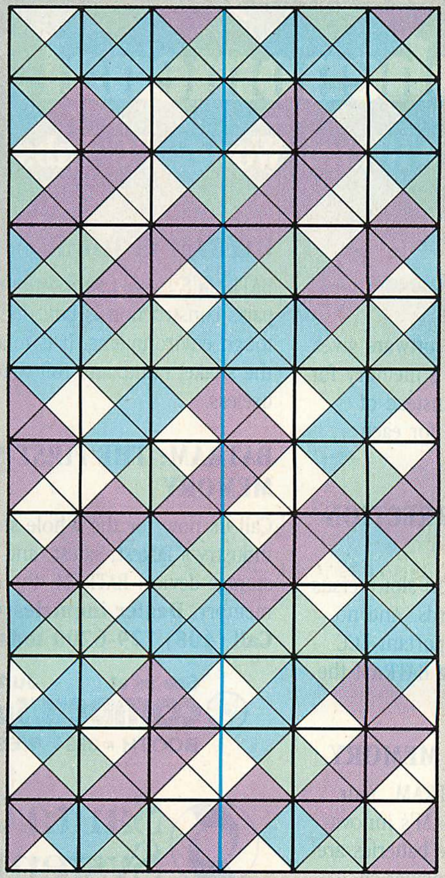
—Richard Schwartz and Robert Shostak

THREE-PIECE DOMINO SOLUTION



The three-domino set is unsolvable. None of the dominoes can cover the plane by itself. Moreover, the only way they combine vertically is as shown. A solution must consist of an infinite vertical column formed by stacking three blocks. Because the column's left edge does not mate with the right edge, no solution is possible.

TEN-PIECE DOMINO SOLUTION



Several solutions exist for the ten-piece set. This figure shows a solution similar to one published by Hao Wang in November 1965. It is formed by a repeating 3-by-12 block, two instances of which are shown side-by-side.

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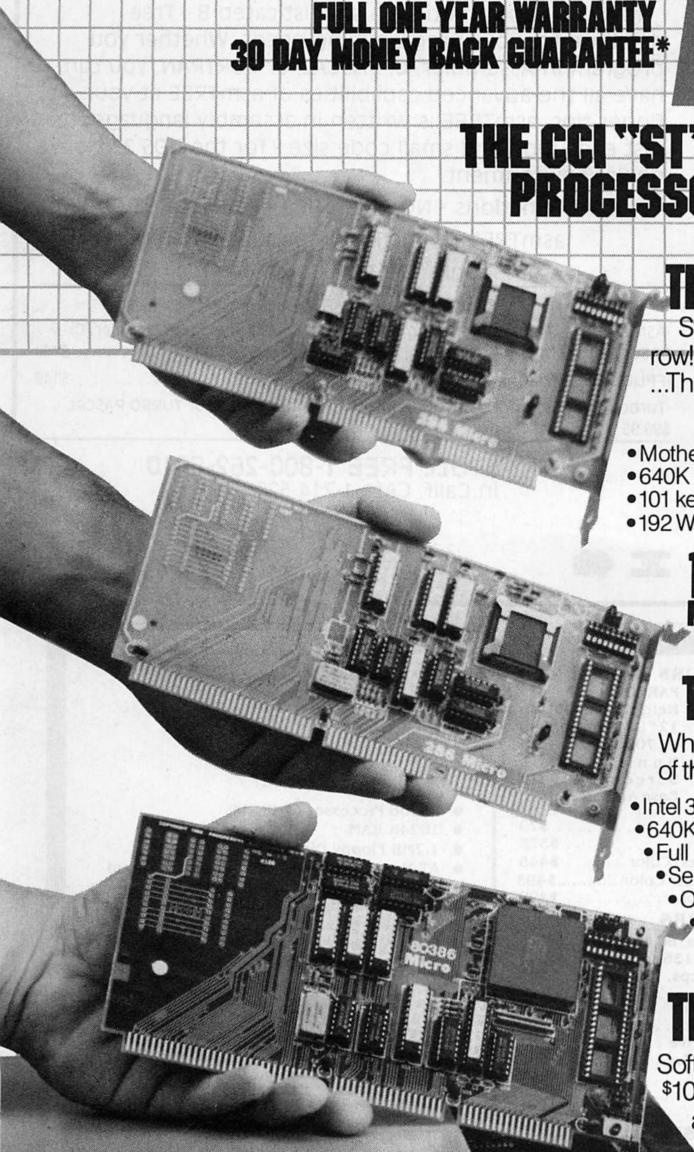

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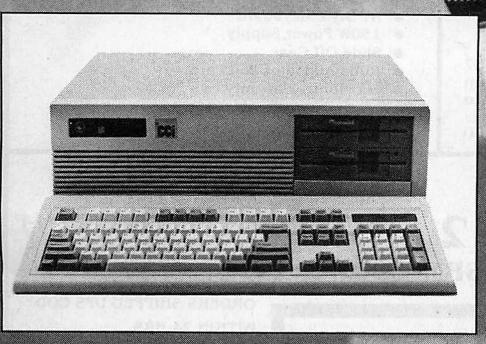

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PRODUCT CATEGORIES

HARDWARE 212-213

SOFTWARE 214-221

SOFTWARE *continued*

MISCELLANEOUS 221

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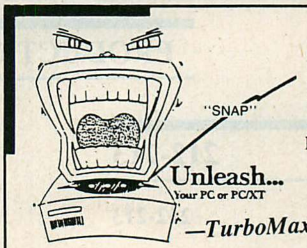

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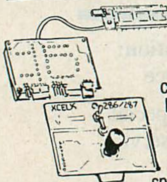

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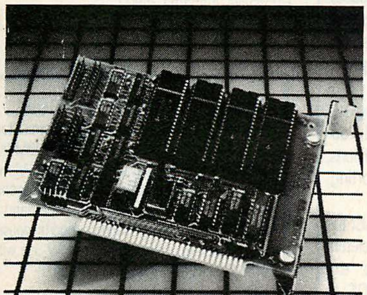

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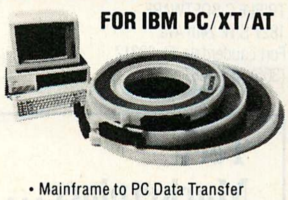

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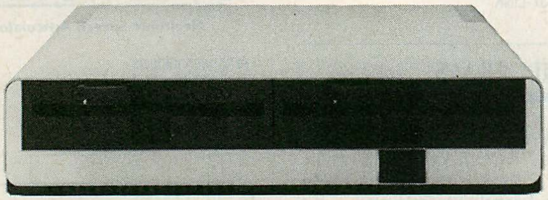

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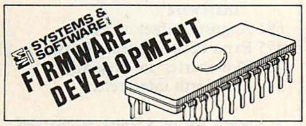

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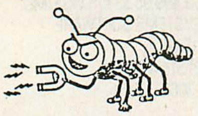

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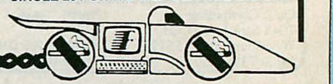

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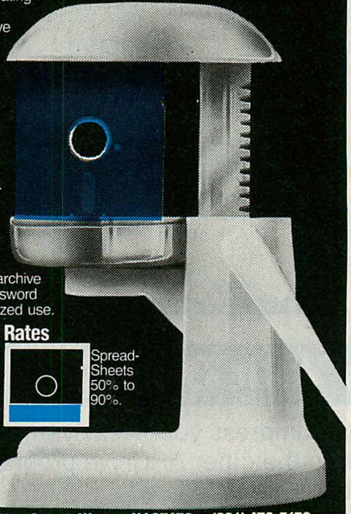

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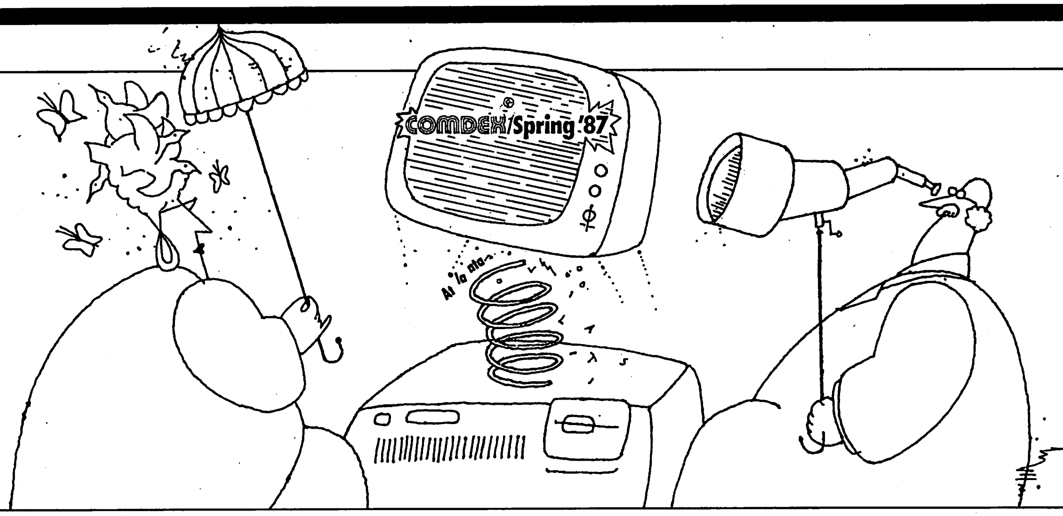

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JUNE

June 1–4
COMDEX/Spring
Atlanta, GA (Interface Group) *Contact:* The Interface Group, Inc., 300 First Ave., Needham, MA 02194; 617/449-6600

June 3–5
AI/Europa '87
Frankfurt, W. Germany (Tower Conference Management) *Contact:* TCM, 331 W. Wesley St., Wheaton, IL 60187; 312/668-8100

June 3–5
Research and Development on Information Retrieval
New Orleans, LA (ACM SIGIR and ACM SIGART) *Contact:* Donald H. Kraft, CS Dept., Louisiana State University, Baton Rouge, LA 70803; 504/388-1495

June 8–12
USENIX Technical Conference and Exhibition
Phoenix, AZ (USENIX) *Contact:* USENIX Conference Office, P.O. Box 385, Sunset Beach, CA 90742; 213/592-1381

June 11
Next Generation Information Systems
Gaithersburg, MD (ACM and U.S. Deparment of Commerce) *Contact:* U.S. Department of Commerce, National Bureau of Standards, Gaithersburg, MD 20899; 301/290-6208

June 11–12
Manager's Guide to End User Computing
Atlanta, GA (Georgia Institute of Technology) *Contact:* Deidre Mercer, Department of Continuing Education, Georgia Institute of Technology, Atlanta, GA 30332-0385; 404/894-2547

June 15–17
IBM's SNA: Security and Audit Concerns
Chicago, IL (MIS Training Institute) *Contact:* Michael I. Sobol, 4 Brewster Rd., Framingham, MA 01701; 617/879-7999

June 15–18
1987 National Computer Conference
Chicago, IL (AFIPS and ACM) *Contact:* NCC 87, AFIPS, 1899 Preston White Dr., Reston, VA 22091; 800/622-1987; in Virginia, 703/620-8955

June 23–26
AutoCAD Expo '87
Washington, DC (Autodesk) *Contact:* Autodesk Marketing Productions, Autodesk, Inc., 2320 Marinship Way, Sausalito, CA 94965; 415/332-2344 ext. 799

June 24–26
Interpreters and Interpretive Techniques
St. Paul, MN (ACM SIGPLAN and IEEE-CS) *Contact:* Mark Scott Johnson, HP Labs, 1501 Page Mill Rd. 3u24, Palo Alto, CA 94304-1181; 415/857-8719

JULY

July 6–16
Summer Institute on Educational Computing
New Rochelle, NY (Iona College) *Contact:* Brian Monahan, CIS Dept., Iona College, New Rochelle, NY 10801; 914/633-2578

July 21–23
The Future of Optical Memory Technology
San Francisco, CA (Rothchild Consultants) *Contact:* Rothchild Consultants, 256 Laguna Honda Blvd., San Francisco, CA 94116-1496; 415/681-3700

July 22–23
National Financial and Computer Automation Conference
New York, NY (PC EXPO) *Contact:* Jim Mion, PC EXPO, 333 Sylvan Ave., Englewood Cliffs, NJ 07632; 800/237-7601; in New Jersey, 201/569-6474

July 27–31
SIGGRAPH '87
Anaheim, CA (ACM SIGGRAPH) *Contact:* SIGGRAPH '87 Conference Management, Smith, Bucklin, and Associates, Inc., 111 E. Wacker Dr., Suite 600, Chicago, IL 60601; 312/644-6610

July 29–31
AI and Knowledge-based Systems: Realizing the Potential
San Francisco, CA (Decision Support Technology) *Contact:* DST, Conference Registration Office, 51 Church St., Boston, MA 02116; 800/843-3263; in Massachusetts, 617/482-3596

AUGUST

August 17–21
Parallel Processing
St. Charles, IL (Pennsylvania State University) *Contact:* Sartaj K. Sahni, CS Dept., 136 Lind Hall, University of Minnesota, Minneapolis, MN 55455

August 17–20
Engineering/Manufacturing '87
Boston, MA (National Computer Graphics Assn.) *Contact:* NCGA, 2722 Merrilee Dr., Suite 200, Fairfax, VA 22031; 703/698-9600

August 19–21
COMDEX/Australia
Sydney, Australia (Interface Group) *Contact:* The Interface Group, Inc., 300 First Ave., Needham, MA 02194; 617/449-6600

August 22–28
IJCAI '87
Milan, Italy (International Joint Conferences on AI) *Contact:* John McDermott, CS Dept., Carnegie-Mellon University, Pittsburgh, PA 15213; 415/328-3123

August 24–28
AAAI '87
Seattle, WA (American Association for AI) *Contact:* Lorraine Cooper, AAAI, 445 Burgess, Menlo Park, CA 94025; 415/328-3123

SEPTEMBER

September 1–3
PC EXPO
New York, NY (PC EXPO) *Contact:* Jim Mion, PC EXPO, 333 Sylvan Ave., Englewood Cliffs, NJ 07632; 800/922-0324; in New Jersey, 201/569-8542

September 21–23
Conference on Software Maintenance
Austin, TX (U.S. Department of Commerce, National Bureau of Standards, and IEEE-CS) *Contact:* Roger Martin, U.S. Department of Commerce, National Bureau of Standards, Building 225, Room B266, Gaithersburg, MD 20899; 301/921-3545

September 28–October 1
Conference on Electronic/Desktop Publishing
San Francisco, CA (National Computer Graphics Association) *Contact:* National Computer Graphics Association, 2722 Merrilee Dr., Suite 200, Fairfax, VA 22031; 703/698-9600

OCTOBER

October 13–15
PC EXPO/Chicago
Chicago, IL (PC EXPO) *Contact:* Jim Mion, PC EXPO, 333 Sylvan Ave., Englewood Cliffs, NJ 07632; 800/922-0324; in New Jersey, 201/569-8542

October 15–17
Northeast Computer Faire
Boston, MA (Interface Group) *Contact:* The Interface Group, Inc., 300 First Ave., Needham, MA 02194; 617/449-6600

October 20–22
NetWorld '87
Dallas, TX (PC EXPO) *Contact:* Annie Zdinak, PC EXPO, 333 Sylvan Ave., Englewood Cliffs, NJ 07632; 800/526-3247; in New Jersey, 201/569-6409

October 20–22
UNIX EXPO
New York, NY (National Expositions Company) *Contact:* National Expositions Company, Inc., 49 W. 38th St., Suite 12A, New York, NY 10018; 212/391-9111

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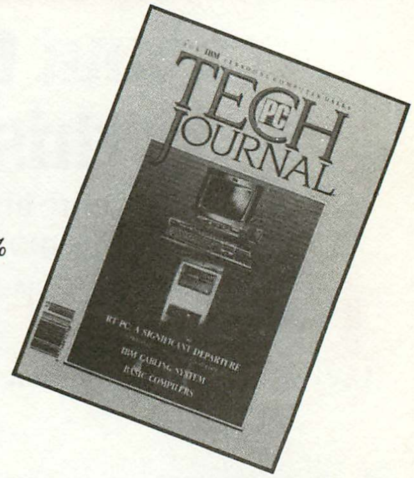

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Starting at $1990, ALR's totally new 386/2 systems couple the power of 32-bit processing with true 32-bit memory. Even the system and graphics BIOS are implemented in a 32-bit architecture. That simply means your applications will run faster on a 386/2 than any other available computer. And ALR 386/2 systems let you use all the peripherals, graphics, enhancements and applications developed for the most widely adopted computer operating environment in history.

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How to run circles around the competition.

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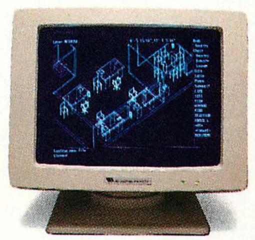


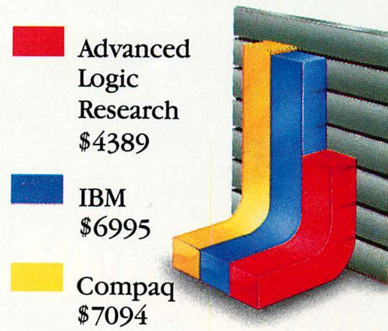
The 386/2 series makes the best use of floor or desk space.

You can even run up to nine applications at once. Without memory limitations. Because all enhanced ALR systems include the bestselling multitasking software Desqview,™ as well as QEMM,™ an EMS management utility.

See us at Spring Comdex Atlanta, booth 3522

Speed to burn. Without having money to burn.

Read the reviews and compare the 386/2 to the others. Then compare more. If you find more power, flexibility and quality somewhere else, buy somewhere else. You won't find a more competitive price anywhere else.



The ALR 386/2 Model 40 with EGA adapter is similar to the IBM Model 80-041 and Compaq Deskpro 386 Model 40 with EGA adapter. Except for a lower price and twice their standard RAM.

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- 10 MHz 80287 support
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- 1.2 MB floppy disk drive
- Serial and parallel ports
- 8 expansion slots
- 101-key keyboard

386/2 Model 40 — $3990

- ALR-designed system board
- 16 MHz 80386 processor
- 10 MHz 80287 support
- 2 MB 32-bit RAM
- 40 MB, 30 ms, or less, access time hard disk drive
- EMS and multitasking software
- 1.2 MB floppy disk drive
- Serial and parallel ports
- Desktop or floormount
- 8 expansion slots
- 101-key keyboard

386/2 Model 80 — $4690

- ALR-designed system board
- 16 MHz 80386 processor
- 10 MHz 80287 support
- 2 MB 32-bit RAM
- 70 MB, 30 ms, or faster, access time hard disk drive
- EMS and multitasking software
- 1.2 MB floppy disk drive
- Serial and parallel ports
- Desktop or floormount
- 8 expansion slots
- 101-key keyboard

386/2 Model 130 — $7299

- ALR-designed system board
- 16 MHz 80386 processor
- 10 MHz 80287 support
- 2 MB 32-bit RAM
- 130 MB, 30 ms, or faster, access time hard disk drive
- EMS and multitasking software
- 1.2 MB floppy disk drive
- Serial and parallel ports
- 8 expansion slots
- 101-key keyboard

Enhancements

A complete range of enhancements, including 4 MB 32-bit RAM and multifunction products as well as additional I/O options are available. 640 x 480 pixel AV EGA with 16 colors and GA 786 graphics adapters available third quarter.

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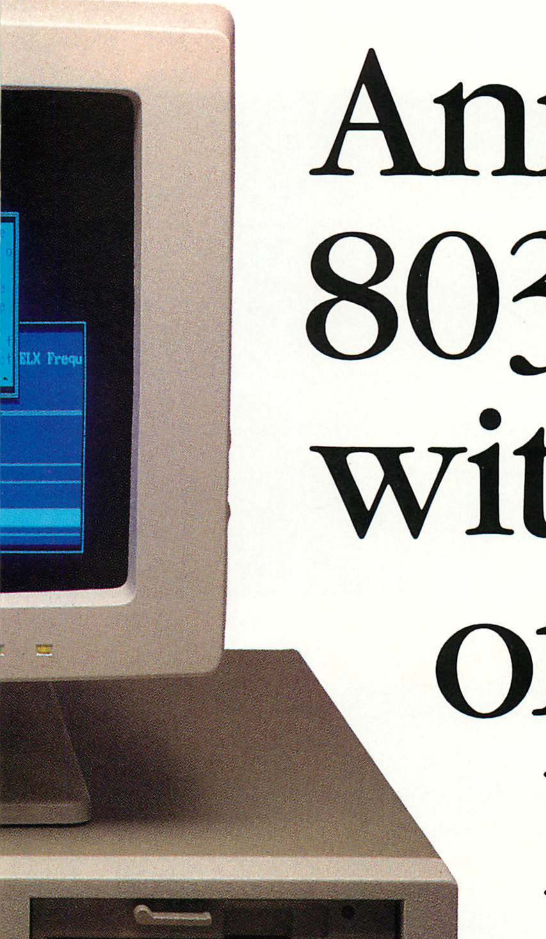


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